**At 1st stage we plan to focus on mechanosensory (looks not so complex as, for example, chemosensory system) and possibly light-sensory systems (according to actual information there are only 6 of them). We plan to add a model of sensory system to already existing muscle-body-environment model implemented within Sibernetic simulation environment.**

**Mechanosensation**

It is supposed that there are 30 mechanosensory neurons, 12 - over body surface, 18 - at worm head tip.

## Book: C. Elegans: Methods and Applications

## editor: Kevin Strange

Of interest: 5.1. Primary Sensory Neuron Recordings

[http://bo.google.ru/books?id=xCYEnIOggwUC&pg=PA186&lpg=PA186&dq=c+elegans+sensory+neurons+recordoksings&source=bl&ots=354\_fyk0K9&sig=CTByzwRUwKO36eNF6HAhYCxWKGA&hl=ru&sa=X&ei=zHm2Uva4A4efyQPz0YCgBQ&ved=0CF4Q6AEwBQ#v=onepage&q=c%20elegans%20sensory%20neurons%20recordings&f=false](http://books.google.ru/books?id=xCYEnIOggwUC&pg=PA186&lpg=PA186&dq=c+elegans+sensory+neurons+recordings&source=bl&ots=354_fyk0K9&sig=CTByzwRUwKO36eNF6HAhYCxWKGA&hl=ru&sa=X&ei=zHm2Uva4A4efyQPz0YCgBQ&ved=0CF4Q6AEwBQ#v=onepage&q=c%20elegans%20sensory%20neurons%20recordings&f=false)

**WormBook. Mechanosensation.**

<http://www.wormbook.org/chapters/www_mechanosensation/mechanosensation.html>

WormBook. Hermaphrodite sensory receptors table:

<http://wormatlas.org/hermaphrodite/nervous/Images/neurotable1leg.htm>

## Crosstalk among C. elegans sensory neurons regulates nociceptor responses

<http://www.painresearchforum.org/news/6228-crosstalk-among-c-elegans-sensory-neurons-regulates-nociceptor-responses>

**WormAtlas.org. Link to one of sensory neurons detailed information:**

<http://www.wormatlas.org/neurons/Individual%20Neurons/ALMframeset.html>

**In Vivo Imaging of C. elegans Mechanosensory Neurons Demonstrates a Specific Role for the MEC-4 Channel in the Process of Gentle Touch Sensation**

Hiroshi Suzuki, Rex Kerr, Laura Bianchi, Christian Frøkjær-Jensen, Dan Slone,

Jian Xue, Beate Gerstbrein, Monica Driscoll, and William R. Schafer

<http://www2.mrc-lmb.cam.ac.uk/groups/wschafer/Suzuki2003.pdf>

**Mechanosensitive Ion Channels in Caenorhabditis elegans**

Dafne Bazopoulou and Nektarios Tavernarakis

<http://elegans.imbb.forth.gr/worms/PDF/MecDB.pdf>

**The Neural Circuit for Touch Sensitivity in Caenorhabditis elegans’**

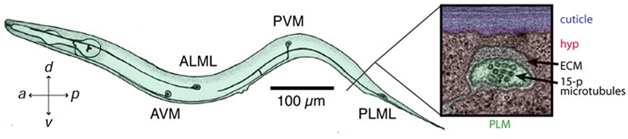
MARTIN CHALFIE, JOHN E. SULSTON, JOHN G. WHITE\* EILEEN SOUTHGATE\*

J. NICHOL THOMSON, AND SYDNEY BRENNERS

<http://www.jneurosci.org/content/5/4/956.full.pdf>

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**The six touch receptor neurons (**[**ALML**](http://www.wormbase.org/db/get?name=ALML;class=Cell)**,** [**ALMR**](http://www.wormbase.org/db/get?name=ALMR;class=Cell)**,** [**AVM**](http://www.wormbase.org/db/get?name=AVM;class=Cell)**,** [**PLML**](http://www.wormbase.org/db/get?name=PLML;class=Cell)**,** [**PLMR**](http://www.wormbase.org/db/get?name=PLMR;class=Cell)**,** [**PVM**](http://www.wormbase.org/db/get?name=PVM;class=Cell)**) extend long processes that innervate approximately one-half of the animal’s body length (**[**Figure 1**](http://www.wormbook.org/chapters/www_mechanosensation/mechanosensation.html#figure1)**).**



**Their processes are filled with unusual, 15-protofilament (15-p) microtubules that are cross-linked to one another and arrayed such that their distal ends are in close apposition to the cell membrane (**[**Chalfie and Thomson, 1979**](http://www.wormbook.org/chapters/www_mechanosensation/mechanosensation.html#bib8)**). The 15-p microtubules are unique to the touch receptor neurons (**[**Chalfie and Sulston, 1981**](http://www.wormbook.org/chapters/www_mechanosensation/mechanosensation.html#bib6)**) and arise from tubulins (**[**MEC-7**](http://www.wormbase.org/db/seq/protein?name=MEC-7;class=protein) **and** [**MEC-12**](http://www.wormbase.org/db/seq/protein?name=MEC-12;class=protein)**) abundant in touch receptor neurons (**[**Fukushige et al., 1999**](http://www.wormbook.org/chapters/www_mechanosensation/mechanosensation.html#bib19)**;** [**Savage et al., 1989**](http://www.wormbook.org/chapters/www_mechanosensation/mechanosensation.html#bib48)**). Ultrastructural specializations are not restricted to the cytoskeleton, however. Touch receptor neurons are tightly coupled to the animal’s skin or cuticle, engulfed by hypodermal cells, and surrounded by an electron-dense extracellular matrix or ECM (**[**Chalfie and Sulston, 1981**](http://www.wormbook.org/chapters/www_mechanosensation/mechanosensation.html#bib6)**). Because they are the only neurons whose processes are in such close contact with the cuticle along their length, touch receptor neurons are uniquely positioned to detect external forces applied to the animal’s body wall, as well as internal forces generated during locomotion.**

[**http://ac.els-cdn.com/S0896627303005397/1-s2.0-S0896627303005397-main.pdf?\_tid=99b0a22e-d5bb-11e3-bfcb-00000aacb35e&acdnat=1399448926\_ea553d05a9e57e2204579c4b4f7bb2f0**](http://ac.els-cdn.com/S0896627303005397/1-s2.0-S0896627303005397-main.pdf?_tid=99b0a22e-d5bb-11e3-bfcb-00000aacb35e&acdnat=1399448926_ea553d05a9e57e2204579c4b4f7bb2f0)

**In Vivo Imaging of C. elegans Mechanosensory Neurons Demonstrates a Specific Role for the MEC-4 Channel in the Process of Gentle Touch Sensation**

**Our strategy was to use the genetically encoded indicator cameleon to monitor the activity of touch neurons in response to controlled mechanosensory stimuli. Cameleons are multidomain proteins that include YFP and CFP moieties linked by calmodulin and a calmodulin binding peptide; when Ca2+ binds the calmodulin domain, conformational changes allow fluorescence resonance energy transfer between YFP and CFP such that ratios of fluorescence signals reflects intracellular Ca2+ changes.**

|  |  |
| --- | --- |
|  | **Stimulus-response latency. Average response in the ALM cell body elicited by a 90 ms poke approximately 350 µm anterior to the cell body. Sample rate is 88 Hz. A statistically significant (p = 0.001) rise is observed 45 ms after the onset of stimulation (closed**  **circles) as compared to the baseline 50 ms prior to stimulation.** |

**The signal passes a distance of 350 micrometers during a time of 45 ms, so velocity of signal propagation = 7.7 µm/ms = 7.7 mm/s**

**All three classes of touch neurons, ALM, AVM, and PLM (Chalfie et al., 1985), exhibited reliable calcium responses when we delivered stimuli to the appropriate sensory region (anterior body for ALM and AVM, posterior body for PLM) and responded less reliably or not at all when the inappropriate body region was stimulated (data not shown; see also Figure 3F)**

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# **The neural circuits and sensory channels mediating harsh touch sensation in Caenorhabditis elegans.**

[Li W](http://www.ncbi.nlm.nih.gov/pubmed?term=Li%20W%5BAuthor%5D&cauthor=true&cauthor_uid=21587232), [Kang L](http://www.ncbi.nlm.nih.gov/pubmed?term=Kang%20L%5BAuthor%5D&cauthor=true&cauthor_uid=21587232), [Piggott BJ](http://www.ncbi.nlm.nih.gov/pubmed?term=Piggott%20BJ%5BAuthor%5D&cauthor=true&cauthor_uid=21587232), [Feng Z](http://www.ncbi.nlm.nih.gov/pubmed?term=Feng%20Z%5BAuthor%5D&cauthor=true&cauthor_uid=21587232), [Xu XZ](http://www.ncbi.nlm.nih.gov/pubmed?term=Xu%20XZ%5BAuthor%5D&cauthor=true&cauthor_uid=21587232)

# **C. elegans multi-dendritic sensory neurons: morphology and function.**

[Albeg A](http://www.ncbi.nlm.nih.gov/pubmed?term=Albeg%20A%5BAuthor%5D&cauthor=true&cauthor_uid=20971193), [Smith CJ](http://www.ncbi.nlm.nih.gov/pubmed?term=Smith%20CJ%5BAuthor%5D&cauthor=true&cauthor_uid=20971193), [Chatzigeorgiou M](http://www.ncbi.nlm.nih.gov/pubmed?term=Chatzigeorgiou%20M%5BAuthor%5D&cauthor=true&cauthor_uid=20971193), [Feitelson DG](http://www.ncbi.nlm.nih.gov/pubmed?term=Feitelson%20DG%5BAuthor%5D&cauthor=true&cauthor_uid=20971193), [Hall DH](http://www.ncbi.nlm.nih.gov/pubmed?term=Hall%20DH%5BAuthor%5D&cauthor=true&cauthor_uid=20971193), [Schafer WR](http://www.ncbi.nlm.nih.gov/pubmed?term=Schafer%20WR%5BAuthor%5D&cauthor=true&cauthor_uid=20971193), [Miller DM 3rd](http://www.ncbi.nlm.nih.gov/pubmed?term=Miller%20DM%203rd%5BAuthor%5D&cauthor=true&cauthor_uid=20971193), [Treinin M](http://www.ncbi.nlm.nih.gov/pubmed?term=Treinin%20M%5BAuthor%5D&cauthor=true&cauthor_uid=20971193)**.**

Marios Chatzigeorgiou, Sungjae Yoo, Joseph D. Watson, Wei-Hsiang Lee, W. Clay Spencer, Katie S. Kindt, Sun Wook Hwang, David M. Miller, III, Millet Treinin, Monica Driscoll, William R. Schafer (2010) **Specific roles for DEG/ENaC and TRP channels in touch and thermosensation in C. elegans nociceptors.** [**Nature Neurosci. 13, 861-868**](http://www.ncbi.nlm.nih.gov/pubmed/20512132)**.** PMCID:PMC2975101

Cody J. Smith, \*Joseph D. Watson, W. Clay Spencer, Tim O’Brien, Byeong Cha, Adi Albeg, Millet Treinin, David M. Miller, III (2010) **Time-lapse imaging and cell-specific expression profiling reveal dynamic branching and molecular determinants of a multi-dendritic nociceptor in C. elegans.** [**Developmental Biol. 345, 18-33**](http://www.ncbi.nlm.nih.gov/pubmed/20537990)**.** PMID: 20537990. \*These authors contributed equally

CS Smith, JD Watson, MK Van Hoven, DA Colon-Ramos, DM Miller, III. (2012) **Netrin (UNC-6) mediates dendritic self-avoidance.** [**Nature Neuroscience 15, 731-737**](http://www.ncbi.nlm.nih.gov/pubmed/22426253)**.** PMCID: PMC3337961 <http://medicine.yale.edu/labs/colon-ramos/www/Publications/2012%20Smith%20Colon-Ramos%20Netrin%20mediates_NatNeuro.pdf>

SJ Husson, WS Costa, JN Stirman, JD Watson, WC Spencer, DM Miller, III, H Lu, A Gottschalk (2012). **Optogenetic analysis of a nociceptor neuron and network reveals ion channels acting downstream of primary sensors.** [**Current Biology 22, 743-752**](http://www.ncbi.nlm.nih.gov/pubmed/22483941)**.** PMCID: PMC3350619.

# **Sensory neuron fates are distinguished by a transcriptional switch that regulates dendrite branch stabilization.**

[Smith CJ](http://www.ncbi.nlm.nih.gov/pubmed?term=Smith%20CJ%5BAuthor%5D&cauthor=true&cauthor_uid=23889932), [O'Brien T](http://www.ncbi.nlm.nih.gov/pubmed?term=O%27Brien%20T%5BAuthor%5D&cauthor=true&cauthor_uid=23889932), [Chatzigeorgiou M](http://www.ncbi.nlm.nih.gov/pubmed?term=Chatzigeorgiou%20M%5BAuthor%5D&cauthor=true&cauthor_uid=23889932), [Spencer WC](http://www.ncbi.nlm.nih.gov/pubmed?term=Spencer%20WC%5BAuthor%5D&cauthor=true&cauthor_uid=23889932), [Feingold-Link E](http://www.ncbi.nlm.nih.gov/pubmed?term=Feingold-Link%20E%5BAuthor%5D&cauthor=true&cauthor_uid=23889932), [Husson SJ](http://www.ncbi.nlm.nih.gov/pubmed?term=Husson%20SJ%5BAuthor%5D&cauthor=true&cauthor_uid=23889932), [Hori S](http://www.ncbi.nlm.nih.gov/pubmed?term=Hori%20S%5BAuthor%5D&cauthor=true&cauthor_uid=23889932), [Mitani S](http://www.ncbi.nlm.nih.gov/pubmed?term=Mitani%20S%5BAuthor%5D&cauthor=true&cauthor_uid=23889932), [Gottschalk A](http://www.ncbi.nlm.nih.gov/pubmed?term=Gottschalk%20A%5BAuthor%5D&cauthor=true&cauthor_uid=23889932), [Schafer WR](http://www.ncbi.nlm.nih.gov/pubmed?term=Schafer%20WR%5BAuthor%5D&cauthor=true&cauthor_uid=23889932), [Miller DM 3rd](http://www.ncbi.nlm.nih.gov/pubmed?term=Miller%20DM%203rd%5BAuthor%5D&cauthor=true&cauthor_uid=23889932).

Oren-Suissa, M., Hall, D.H., Treinin, M., Shemer, G., and Podbilewicz, B. (2010) **The fusogen EFF-1 controls sculpting of mechanosensory dendrites. Science 328: 1285-8.** [**Abstract**](http://dx.doi.org/DOI:10.1126/science.1189095)

Mitani, S., Du, H., Hall, D.H., Driscoll, M. and Chalfie, M. (1993) **Combinatorial control of touch receptor expression in *Caenorhabditis elegans*. Development 119: 773-783.** [**Abstract**](http://www.wormbase.org/db/misc/paper?name=WBPaper00001829;class=Paper) [**Article**](http://dev.biologists.org/cgi/reprint/119/3/773)

**Temperature- and Touch-Sensitive Neurons Couple CNG and TRPV Channel Activities to Control Heat Avoidance in *Caenorhabditis elegans***

Shu Liu, Ekkehard Schulze, Ralf Baumeister

<http://www.plosone.org/article/info:doi%2F10.1371%2Fjournal.pone.0032360>

# **Mechanotransduction: touch and feel at the molecular level as modeled in Caenorhabditis elegans.**

<http://www.ncbi.nlm.nih.gov/pubmed/17955200>

**Locomotion**

**Gait modulation in C. elegans: An integrated neuromechanical model**

Boyle Jordan Hylke, Berri Stefano, Cohen Netta

JOURNAL=Frontiers in Computational Neuroscience VOLUME=6 YEAR=2012

NUMBER=00010 RT\_DOI=10.3389/fncom.2012.00010 DOI=10.3389/fncom.2012.00010 ISSN=1662-5188

<http://www.frontiersin.org/Journal/Abstract.aspx?s=237&name=computational_neuroscience&A>

## Synaptic polarity of the interneuron circuit controlling C. elegans locomotion*.*

## *Rakowski F, Srinivasan J, Sternberg P Wand Karbowski J (2013) Synaptic polarity of the interneuron circuit controlling C. elegans locomotion. Front. Comput. Neurosci. 7:128. doi: 10.3389/fncom.2013.00128*

## <http://www.frontiersin.org/Computational_Neuroscience/10.3389/fncom.2013.00128/abstract>

## Light-sensation

## Light-sensitive neurons and channels mediate

## phototaxis in C. elegans (Nature neuroscience, 2008)

<http://libgen.org/scimag3/10.1038/nn.2155.pdf>

## Potentially relevant models on OpenWorm/Open Source Brain

“Main” c elegans in NeuroML project. Currently contains the multicompartmental neuron model in NeuroML:

<http://www.opensourcebrain.org/projects/celegans>

The muscle cell model in NeuroML 2

<http://www.opensourcebrain.org/projects/muscle_model>

Model of a drosophila stretch receptor:

<http://www.opensourcebrain.org/projects/dbdflymodel>

Model of a drosophila motor neuron

<http://www.opensourcebrain.org/projects/drosophila-acc-l3-motoneuron-gunay-et-al-2014>