Life Sciences 92 (2013) 394–403

Contents lists available at SciVerse ScienceDirect

Life Sciences

journal homepage: www.elsevier.com/locate/lifescie

Minireview

Drosophila TRP channels and animal behavior

Melissa A. Fowler, Craig Montell *

Department of Biological Chemistry, Center for Sensory Biology, The Johns Hopkins University School of Medicine, Baltimore, MD 21205, USA
Department of Neuroscience, Center for Sensory Biology, The Johns Hopkins University School of Medicine, Baltimore, MD 21205, USA

ARTICLE INFO

Article history:
Received 23 May 2012
Accepted 16 July 2012

Keywords:
TRP channels
Drosophila
Behavior
Sensory signaling
Thermosensation
Taste
Smell
Vision
Mechanosensation
Phospholipase C
Gustatory
Olfactory
Phototransduction
Calcium
Proprioception

ABSTRACT

Multiple classes of cell surface receptors and ion channels participate in the detection of changes in environmental stimuli, and thereby influence animal behavior. Among the many classes of ion channels, Transient Receptor Potential (TRP) cation channels are notable in contributing to virtually every sensory modality, and in controlling a daunting array of behaviors. TRP channels appear to be conserved in all metazoan organisms including worms, insects and humans. Flies encode 13 TRPs, most of which are expressed and function in sensory neurons, and impact behaviors ranging from phototaxis to thermotaxis, gravitaxis, the avoidance of noxious tastants and smells and proprioception. Multiple diseases result from defects in TRPs, and flies provide an excellent animal model for dissecting the mechanisms underlying "TRPopathies." *Drosophila* TRPs also function in the sensation of botanically derived insect repellents, and related TRPs in insect pests are potential targets for the development of improved repellents to combat insect-borne diseases.

Contents

* Corresponding author at: Department of Biological Chemistry, Center for Sensory Biology, The Johns Hopkins University School of Medicine, Baltimore, MD 21205, USA. Tel.: +1 410 955 1199.
E-mail address: cmontell@jhmi.edu (C. Montell).

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http://dx.doi.org/10.1016/j.lfs.2012.07.029

Introduction

The Transient Receptor Potential (TRP) superfamily of ion channels comprises a collection of cation channels conserved from worms to flies and humans (Ramsey et al., 2006; Venkatachalam and Montell, 2007). The channels are arranged into seven subfamilies based on primary amino acid sequence homology (TRPC, TRPV, TRPA, TRPN, TRPM, TRPML, and TRPP) (Montell, 2005; Montell et al., 2002). TRPs are activated through a wide variety of mechanisms and participate in virtually every sensory modality (Table 1). Since the cloning and characterization of the gene encoding the *Drosophila* TRP channel, which functions in phototransduction (Montell and Rubin, 1989), twelve other fly TRP channels have been identified (Fig. 1). These channels are critical for sensing the external environment, and function in vision, thermosensation, olfaction, taste, hygrosensation, and mechanosensation. Consequently, these channels have a profound impact on animal behavior. Due to their genetic tractability, flies are an outstanding animal model for studying TRP channel function in the contexts of sensory physiology and animal behavior.

Light sensation

TRP and TRPL and phototransduction in the adult visual systems

Light sensation in adult fruit flies contributes to a variety of behaviors such as the recognition of visual cues that initiate courtship,

Table 1
Properties of *Drosophila* Transient Receptor Potential (TRP) channels.

TRP channels with known sensory roles					
Sub family	Channel	Abbrev.	Selectivity P_{Ca}/P_{Na}	Physiological modes of activation	Sensory functions
TRPC	Transient Receptor Potential	TRP	25–40	G_q/PLC signaling, PUFA, H^+, PIP_2 depletion	• Phototransduction
	TRP-Like	TRPL	Nonselec. cation	G_q/PLC signaling, PUFA, H+, PIP_2 depletion	• Phototransduction • Cold sensation
	TRPγ	TRPγ	Nonselec. cation	G_q/PLC signaling, PUFA	–
TRPA	TRPA1	TRPA1	–	Heat (>26 °C) reactive electrophiles (AITC, NMM, CA) Temp (18-24 °C, Rh1/PLC signaling) arist. acid (G_q/PLC sig.), citronellal (G_q/PLC sig.), light	• Warm temperature sensation • Avoidance of noxious heat • Comfortable temperature sensation • Avoidance of aversive non-volatile irritants • Avoidance of aversive tastants • Avoidance of aversive odorants • Avoidance of bright light • Avoidance of mechanical stimulation
	Painless	Pain	40	Heat (~39–42 °C)	• Avoidance of noxious heat • Avoidance of mechanical stimulation Avoidance of dry environments • Gravity sensation
	Pyrexia	Pyx	0.7	Heat (~40 °C)	• Noxious heat resistance • Gravity sensation
	Waterwitch	Wtrw	-	-	• Humid air detection
TRPN	No Mechano-receptor Potential C	NOMPC	–	Mechanical stimulation	• Light touch • Locomotion • Hearing
TRPV	Inactive	Iav	2.8	Hypo-osmotic solution	• Locomotion • Hearing • Gravity sensation • Cold sensation
	Nanchung	Nan	–	Hypo-osmotic solution	• Locomotion • Hearing • Gravity sensation • Dry air detection

TRP channels without known sensory roles					
Sub family	Channel	Abbrev.	Selectivity P_{Ca}/P_{Na}	Physiological modes of activation	Functions
TRPM	TRPM	TRPM	–	–	• Mg^{2+} and Zn^{2+} homeostasis
TRPP	Almost there	Amo	–	–	• Sperm storage
TRPML	TRP Mucolipin	TRPML	–	–	• Locomotion • Autophagy • Clearance of apoptotic cells

Abbreviations: AITC, allyl isothiocyanate; arist. acid, aristolochic acid; NMM, *N*-methyl maleimide; CA, cinnamaldehyde; PLC, phospholipase C; PUFA, polyunsaturated fatty acid; Rh1, Rhodopsin 1.