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主编特约/综述

视网膜中的自主感光神经节细胞

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摘要:

视网膜中少数神经节细胞能够合成感光蛋白——黑视素（melanopsin），因此具备了自主感光的能力，被称为自主感光神经节细胞（intrinsically photosensitive retinal ganglion cells，ipRGCs）。ipRGCs可根据树突形态和分层位置的差异分为五个不同的亚型，其轴突主要投射到视交叉上核、橄榄顶盖前核等脑区，参与调控昼夜节律、瞳孔对光反射等非成像视觉功能。此外，部分ipRGCs的轴突投射到外侧膝状体和上丘，可能在调节成像视觉中发挥功能。本文将概述ipRGCs的发现过程和最新研究进展。

关键词: 黑视素 自主感光神经节细胞 非成像视觉 昼夜节律 视神经投射

Intrinsically Photosensitive Retinal Ganglion Cells

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Abstract:

In addition to photoreceptors, a small percentage of retinal ganglion cells synthesize a novel opsin: melanopsin, therefore are intrinsically photosensitive and are termed intrinsically photosensitive retinal ganglion cells (ipRGCs). Axons of ipRGCs mainly project to the superachiasmatic nucleus (SCN), the intergeniculate leaflet (IGL) and the olivary pretectal nucleus (OPN), mediate non-image-forming vision, such as circadian rhythm entrainment and generating pupillary responses. ipRGCs can be classified into multiple subtypes based on dendritic morphology and level of stratification. Some ipRGCs also project to the lateral geniculate nucleus (LGN), and may involve in regulating image-forming vision. In this article, we review the progress in the past decade since the discovery of ipRGCs.

Keywords: Melanopsin ipRGC Non-image-forming vision Circadian rhythm Optic nerve projection

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参考文献:

1. Keeler CE. Iris movements in blind mice. Am J Physiol, 1927, 81(1): 107~112
2. Provencio I, Foster RG. Circadian rhythms in mice can be regulated by photoreceptors with cone-like characteristics. Brain Res, 1995, 694(1-2): 183~190
3. Provencio I, Jiang G, de Grip WJ, Hayes WP, Rollag MD. Melanopsin: An opsin in melanophores, brain, and eye. Proc Natl Acad Sci USA, 1998, 95(1): 340~345
4. Provencio I, Rodriguez IR, Jiang G, Hayes WP, Moreira EF, Rollag MD. A novel human opsin in the inner retina. J Neurosci, 2000, 20(2): 600~605
5. Gooley JJ, Lu J, Chou TC, Scammell TE, Saper CB. Melanopsin in cells of origin of the retinohypothalamic tract. Nat Neurosci, 2001, 4(12): 1165
6. Hattar S, Liao HW, Takao M, Berson DM, Yau KW. Melanopsin-containing retinal ganglion cells: Architecture, projections, and intrinsic photosensitivity. Science, 2002, 295(5557): 1065~1070
7. Provencio I, Rollag MD, Castrucci AM. Anatomy: Photoreceptive net in the mammalian retina.

Nature, 2002, 415(6871): 493
8. Berson DM, Dunn FA, Takao M. Phototransduction by retinal ganglion cells that set the circadian clock. Science, 2002, 295(5557): 1070~1073
9. Walker MT, Brown RL, Cronin TW, Robinson PR. Melanopsin forms a functional short-wavelength photopigment. Biochemistry, 2003, 42(44): 12734~12738
10. Pires SS, Hughes S, Turton M, Melyan Z, Peirson SN, Zheng L, Kosmaoglou M, Bellingham J, Cheetham ME, Lucas RJ, Foster RG, Hankins MW, Halford S. Differential expression of two distinct functional isoforms of melanopsin (Opn4) in the nammalian retina. J Neurosci, 2009, 29(39): 12332~12342
11. Qiu X, Kumbalasiri T, Carlson SM, Wong KY, Krishna V, Provencio I, Berson DM. Induction of photosensitivity by heterologous expression of melanopsin. Nature, 2005, 433(7027): 745~749
12. Koyanagi M, Kubokawa K, Tsukamoto H, Shichida Y, Terakita A. Cephalochordate melanopsin: Evolutionary linkage between invertebrate visual cells and vertebrate photosensitive retinal ganglion cells. Curr Biol, 2005, 15(11): 1065~1069
13. Lin B, Koizumi A, Tanaka N, Panda S, Masland RH. Restoration of visual function in retinal degeneration mice by ectopic expression of melanopsin. Proc Natl Acad Sci USA, 2008, 105(41): 16009~16014
14. Tu DC, Zhang D, Demas J, Slutsky EB, Provencio I, Holy TE, van Gelder RN. Physiologic diversity and development of intrinsically photosensitive retinal ganglion cells. Neuron, 2005, 48(6): 987~999
15. de Sevilla Müller LP, Do MTH, Yau KW, He S, Baldridge WH. Tracer coupling of intrinsically photosensitive retinal ganglion cells to amacrine cells in the mouse retina. J Comp Neurol, 2010, 518 (23): 4813~4824
16. Schmidt TM, Kofuji P. Functional and morphological differences among intrinsically photosensitive retinal ganglion cells. J Neurosci, 2009, 29(2): 476~482
17. Schmidt TM, Taniguchi K, Kofuji P. Intrinsic and extrinsic light responses in melanopsin-expressing ganglion cells during mouse development. J Neurophysiol, 2008, 100(1): 371~384
18. Berson DM, Castrucci AM, Provencio I. Morphology and mosaics of melanopsin expressing retinal ganglion cell types in mice. J Comp Neurol, 2010, 518(13): 2405~2422
19. Viney TJ, Balint K, Hillier D, Siegert S, Boldogkoi Z, Enquist LW, Meister M, Cepko CL, Roska B. Local retinal circuits of melanopsin-containing ganglion cells identified by transsynaptic viral tracing. Curr Biol, 2007. 17(11): 981~988
20. Hattar S, Kumar M, Park A, Tong P, Tung J, Yau KW, Berson DM. Central projections of melanopsin expressing retinal ganglion cells in the mouse. J Comp Neurol, 2006, 497(3): 326~349
21. Baver SB, Pickard GE, Sollars PJ. Two types of melanopsin retinal ganglion cell differentially innervate the hypothalamic suprachiasmatic nucleus and the olivary pretectal nucleus. Eur J Neurosci, 2008, 27(7): 1763~1770
22. Ecker JL, Dumitrescu ON, Wong KY, Alam NM, Chen SK, LeGates T, Renna JM, Prusky GT, Berson DM, Hattar S. Melanopsin-expressing retinal ganglion-cell photoreceptors: Cellular diversity and role in pattern vision. Neuron, 2010, 67(1): 49~60
23. Wong KY, Dunn FA, Graham DM, Berson DM. Synaptic influences on rat ganglion-cell photoreceptors. J Physiol, 2007, 582(1): 279~296
24. Do MTH, Kang SH, Xue T, Zhong H, Liao HW, Bergles DE, Yau KW. Photon capture and signalling by melanopsin retinal ganglion cells. Nature, 2009, 457(7227): 281~287
25. Schmidt TM, Kofuji P. Differential cone pathway influence on intrinsically photosensitive retinal ganglion cell subtypes. J Neurosci, 2010, 30(48): 16262~16271
26. Hoshi H, Liu WL, Massey SC, Mills SL, ON inputs to the OFF layer: Bipolar cells that break the stratification rules of the retina. J Neurosci, 2009, 29(28): 8875~8883
27. Sekaran S, Lupi D, Jones SL, Sheely CJ, Hattar S, Yau KW, Lucas RJ, Foster RG, Hankins MW. Melanopsin- dependent photoreception provides earliest light detection in the mammalian retina. Curr Biol, 2005, 15(12): 1099~1107
28. Zhang DQ, Wong KY, Sollars PJ, Berson DM, Pickard GE, McMahon DG. Intraretinal signaling by ganglion cell photoreceptors to dopaminergic amacrine neurons. Proc Natl Acad Sci USA, 2008, 105 (37): 14181~14186
29. Ebling FJP. The role of glutamate in the photic regulation of the suprachiasmatic nucleus. Prog in Neurobiol, 1996, 50(2-3): 109~132
30. Hannibal J, Ding JM, Chen D, Fahrenkrug J, Larsen PJ, Gillette MU, Mikkelsen JD. Pituitary adenylate cyclase-activating peptide (PACAP) in the retinohypothalamic tract: A potential daytime regulator of the biological clock. J Neurosci, 1997, 17(7): 2637~2644
31. Bergström AL, Hannibal J, Hindersson P, Fahrenkrug J. Light-induced phase shift in the Syrian hamster (Mesocricetus auratus) is attenuated by the PACAP receptor antagonist PACAP6-38 or PACAP immuno- neutralization. Eur J Neurosci, 2003, 18(9): 2552~2562
32. Babai N, Atlasz T, Tamás A, Reglödi D, Tóth G, Kiss P, Gábriel R. Degree of damage compensation by various pacap treatments in monosodium glutamate-induced retinal degeneration. Neurotox Res, 2005, 8(3): 227~233
33. Seki T, Nakatani M, Taki C, Shinohara Y, Ozawa M, Nishimura S, Ito H, Shioda S. Neuroprotective

effect of PACAP against kainic acid induced neurotoxicity in rat retina. Ann N Y Acad Sci, 2006, 1070 (1): 531~534
34. Güler AD, Ecker JL, Lall GS, Haq S, Altimus CM, Liao HW, Barnard AR, Cahill H, Badea TC, Zhao H. Melanopsin cells are the principal conduits for rod-cone input to non-image-forming vision. Nature, 2008, 453(7191): 102~105
35. Fahrenkrug J, Nielsen HS, Hannibal J. Expression of melanopsin during development of the rat retina. Neuroreport, 2004, 15(5): 781~784
36. Hannibal J, Fahrenkrug J. Melanopsin containing retinal ganglion cells are light responsive from birth. Neuroreport, 2004, 15(15): 2317~2320
37. Johnson J, Wu V, Donovan M, Majumdar S, Renteria RC, Porco T, van Gelder RN, Copenhagen DR. Melanopsin-dependent light avoidance in neonatal mice. Proc Natl Acad Sci USA, 2010, 107(40): 17374~17378
38. Hannibal J, Georg B, Fahrenkrug J. Melanopsin changes in neonatal albino rat independent of rods and cones. Neuroreport, 2007, 18(1): 81~85
39. Dacey DM, Liao HW, Peterson BB, Robinson FR, Smith VC, Pokorny J, Yau KW, Gamlin PD. Melanopsin- expressing ganglion cells in primate retina signal colour and irradiance and project to the LGN. Nature, 2005, 433(7027): 749~754

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