Blue light regulates hair regrowth via the eye

Prof. Sung-Jan Lin (林頌然) from the Institute of Biomedical Engineering and Assoc. Prof. Shih-Kuo Chen (陳示國) from the Department of Life Sciences have published a paper discussing the transmission of external sudden intense light through the intrinsically photosensitive retinal ganglion cell (ipRGC). The suprachiasmatic nucleus (SCN) further stimulates the sympathetic nerves to activate hair follicle stem cells. Stem cells are regulated by the local microenvironment and the systemic environment to remain stationary or activated. How the external environment (meganiche) communicates with stem cells in the body is currently less understood. This achievement will provide a new direction for studies on the regulation of physiological functions and stem cell activity in the body by external light. The paper was published on June 29, 2018 in the Proceedings of the National Academy of Sciences (PNAS).

Prof. Lin is currently the attending physician of the Department of Dermatology (NTUH) and the deputy director of the NTU Research Center for Developmental Biology and Regenerative Medicine. The laboratory has long focused on hair follicle stem cells and hair follicle regeneration. Hair follicles have the property of periodic growth, and the activation of telogen hair follicle stem cells through appropriate stimulation is the key to hair regeneration. Prof. Lin's main research focus is how the outer environment affects stem cells and promotes hair follicle regeneration by regulating microenvironmental factors.

Prof. Chen's laboratory mainly studies how environmental light can influence the physiological functions of animals through the expression of ipRGCs in the retina, such as regulating physiological clocks, energy metabolism, and cognitive behavior. Because melanopsin is highly sensitive to blue light, regular day and night light periods, especially blue light, can affect the animal's sleep, weight metabolism, mood, and learning ability through the ipRGCs.

For many mammals, hair is the first line protection for the skin. Therefore, the regulation of periodic hair regeneration, which can renew damaged hair, is important for the well-being of wild animal. However, how hair follicle stem cells located in the body can respond to changes in external environmental cues remains unclear. This collaborative work between 2 laboratories at the NTU explores this intriguing question.

This study found that mice exposed to bright light (especially blue light) for a few minutes can activate hair follicle stem cells to regenerate new hair. This physiological induction does not rely on the classic vision-forming neuronal circuits such as those involving cone and rod cells. Instead, light signals are interpreted by ipRGCs, which use the blue-light-sensing photopigment melanopsin and transmit light information to the SCN. Subsequently, efferent sympathetic nerves are activated, and local norepinephrine release in the skin promotes hedgehog signaling to activate hair follicle stem cells. This reaction does not affect the original day and night physiological cycle.

This study also revealed previously unknown regulation of autonomic nervous system functions by ipRGCs in the retina, as well as the possibility that multiple neuronal circuits participate in controlling the master clock SCN to modulate distinct physiological functions. For example, when a mouse is stimulated by intense blue light, the heart rate, sweat, and adrenal sympathetic nerve activity all increase. Since mice are nocturnal animals, intense ambient light can be a danger signal that warrants immediate reaction. This rapid regeneration of new hair can provide protection to help animals deal with harsh environmental changes. Therefore, our results suggest that a neuronal circuit from the sensory system to the autonomic nervous system can convey external cues to the peripheral tissue which allows mammals to respond to changing environments.

For detailed research results, please refer to the full text "External light activates hair follicle stem cells through eyes via an ipRGC-SCN-sympathetic neural pathway"; reference website: https://doi.org/10.1073/pnas.1719548115.

References

Fan M-Y, Chang Y-T, Chen C-L, Wang W-H, Pan M-K, Chen W-P, Huang W-Y, Xug Z, Huang H-E, Cheng T, Plikush MV, Chen S-K*, Lin S-J*. External light activates hair follicle stem cells through eyes via an ipRGC–SCN–sympathetic neural pathway. *PNAS*. 2018; 2018 Jul 17;115(29)

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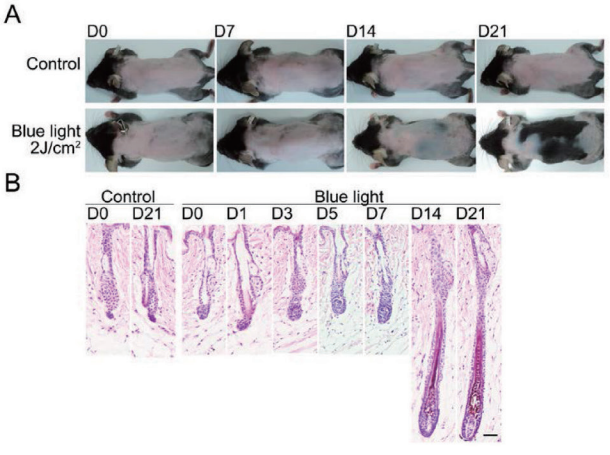

Figure 1. Mouse hair regeneration after blue light exposure (Photo credit: *Fan SMY, et al.* PNAS 2018)

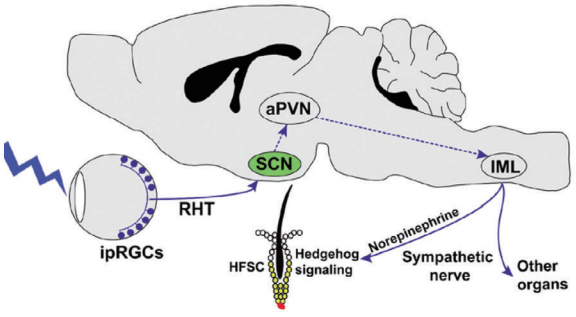

Figure 2. Depiction of the neural pathway for light-stimulated sympathetic activity and hair follicle stem cell activation. (Photo credit: *Fan SMY, et al.* PNAS 2018)