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Mechanisms Controlling Chromatophore Movements in Fishes

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Rapid color changes in animals, including fishes, are due to the motile activity of chromatophores found in the skin. Perceived chiefly by light receptors (either ocular or extraocular), cues from the outside are integrated into efferent signals in the central nervous system to adjust the chromatophores. In fishes, both hormonal and neural systems are operating [1, 2]. Melanophore-stimulating hormone (MSH) from the hypophyseal intermediate lobe disperses pigment granules in species of chromatophores including dermal as well as epidermal melanophores, and bright-colored cells in the dermis. We also found that the action is mediated through MSH-specific receptors on the target cell membrane. Ca^{2+} is necessary to carry out this action. The pineal principle, melatonin, was also shown to affect the pigment cells, i.e., through its specific receptors, it aggregates chromatosomes leading to the blanching of the skin. Evidence indicates that melatonin is responsible for circadian color changes and for the formation of integumental color patterns. Melanin-concentrating hormone (MCH), which originates in the hypothalamus and is secreted from the posterior lobe has also been proven to aggregate chromatosomes through its specific receptors. Sometimes, catecholamines induced pigment dispersion. The effect was brought on by the mediation of beta-adrenoceptors. Epinephrine from adrenal chromaffin cells may be responsible for the physiological darkening reaction. We presume that this system is involved in the excitement darkening which can sometimes be observed. In any case, hormonal means may have evolved to control chromatophore motility slowly, since the process inevitably includes the gradual increase or decrease of their titers in the blood.

Neural regulation, on the other hand, takes a role in adapting fish more rapidly to the environment. It further functions in regulation chromatophores more differentially among portions of the skin to form color patterns. The innervation to the chromatophores is autonomic. Our conclusion is, however, that only the sympathetic division of the system is involved in controlling the cells. Peripheral neuro-transmission is usually adrenergic, and the transmitter is naturally norepinephrine. Being mediated by alpha-adrenoceptors, the transmitter produces an aggregation of chromatosomes in varieties of chromatophores. We found that in silurid catfishes, the transmission is unusually cholinergic, being mediated by muscarinic cholinoceptors. Along with the true transmitter, ATP may be liberated from the nerve-terminals. Converted into adenosine by relevant ecto-enzymes, the co-transmitter may function to counteract the effect of the true one, thus enabling fish to change their hue very quickly. Some other bioactive substances including a few neuropeptides and prostaglandins have been shown to influence the cells, although further work is needed to establish their roles in regulating chromatophore movements. That so many receptor species co-exist on a cell is rather understandable, since the delicate changes in hues and patterns are of utmost importance for animals in the strategy to survive. The many input signals are convergently transduced at the membrane into simpler intracellular phenomena including changes in cyclic AMP and/or Ca^{2+} levels, which lead to the cellular motility. Improvements in experimental methods have greatly facilitated those studies [3].

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1 Fujii, R. (1969) In "Fish Physiology, Vol. 3". Ed. by W. S. Hoar and D. J. Randall, Academic Press, New York, pp. 307–353.
2 Fujii, R. and Oshima, N. (1986) Zool. Sci., **3**: 13–47.
3 Oshima, N. and Fujii, R. (1984) Zool. Sci., **1**: 545–552.