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Introductory Chapter: Melanin, a Versatile Guardian

Miroslav Blumenberg

Additional information is available at the end of the chapter

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The word melanin, from the Greek word ‘melanos’ meaning black, refers to natural pigments produced by the oxidative degradation of the amino acid tyrosine into a variety of products that can self-polymerize into dark insoluble granular material. The first two steps of melanin biosynthesis are catalyzed by tyrosinase, a bifunctional enzyme that converts tyrosine first to dihydroxyphenylalanine (DOPA) and then to dopaquinone. The main function of melanin is to protect the organism from harmful agents such as ultraviolet (UV) radiation; melanin is capable of dissipating over 99% of absorbed UV light. Additionally, melanin can act as an efficient antioxidant, thus alleviating certain types of intracellular chemical damage, as well as protecting from the effects of high temperatures, heavy metals and oxidizing agents, and can play a role in the virulence of fungal pathogens by protecting them from the host’s immune defense mechanisms [1, 2]. Certain organisms repurposed melanin for additional protective functions: ink of cephalopods, octopus, squid and cuttlefish, blackened by melanin, which provides protection from predators [3]. In mollusks other than cephalopods, melanin, together with other chromophores, serves to produce color patterns in their shells [4]. In insects, melanin is used even more resourcefully, not only for pigmentation of the exoskeleton but also for cuticle hardening, wound healing and in their innate immune responses [5]. Melanin in birds is responsible for coloration of the plumage and the exposed bare parts of the integument [6].

In humans, melanin is produced in specialized cells, the melanocytes, found in the basal layer of the epidermis. There are two basic types of melanin in human skin, eumelanin, brown-to-black, and lighter pheomelanin, found in people with red hair. Melanogenesis is enhanced after exposure to UV light, causing the skin to tan. Individuals with darker skin, having more melanin, are partially protected from UV-caused skin cancers. The distinct role of melanin in protecting our skin from deleterious effects of UV radiation has been recently reviewed [7]. Disorders of melanin production, whether acquired, such as vitiligo [8], or congenital, such as oculocutaneous albinism [9], are well-recognized human diseases.

Recently, importance of melanin, both in human diseases and in technological and industrial applications, attracted significant research interests [10]. Melanins, or rather various polydopamines, have found their use in materials science as a coating material for electronics and bioelectronics, in drug delivery systems, as sunscreens, as biofilms, etc. Melanin, thus, ‘evolved’ into a technologically important guardian as well. This necessitates development of

a consensus among researchers on universally accepted and shared nomenclature, methodologies, standards and protocols in melanin research [11]. The current volume is a compilation of unpublished research results in this field.

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