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Melanogenesis and its Ancillary Influences on Biological Activities

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ABSTRACT

Melanogenesis is the production of melanin, a group of pigments found in melanophores. Its major function known to date is photoprotection from ultraviolet radiation. However, it is also shown to be involved in several other biological activities among which are the transplantation and wound healing processes. This study was designed to determine the effects of melanogenesis on the processes of skin transplantation and wound healing. Visual observations and photometric measurements were used to measure the changes. It was discovered that an increase in melanophores in the area of the wound reduced its healing time in Triturus viridescens viridescens (Rafinesque) the experimental organism used in this investigation. Also, a high density of melanophores reduced the time for autoplastic transplants to achieve normality and delayed the dedifferentiation process in homoplastic transplants.

KEYWORDS Melanin, Melanogenesis, Transplantation.

INTRODUCTION

In 1949, I was doing research for my Master of Arts Degree in Biological Sciences at Kent State University. The research was on the effects of the adrenal and thyroid glands on autoplastic and homoplastic skin transplants in *Triturus viridescens viridescens* (Rafinesque). Early into the project, my interest was attracted to the movements and numbers of pigment cells in relation to the transplanted skin. From 1949 to the present, I have continued to research and study various aspects of melanocyte activities including, transplantation, wound healing and melanin synthesis. Long ago I suspected that the functions of melanogenesis and melanocytes far exceeded the well-known function of protection against the deleterious effects of ultraviolet radiation (UV) and in recent years many others have been added. Some of these newer discoveries have supported some of the suspicions I have had for a long time. All of my research indicates that melanin and/or its formation process enhances the wound healing and transplantation processes.

I have also speculated that melanin and melanogenesis contribute to speed, agility, and rhythm among persons of color. However, the explanation for this is not a part of this discussion. In studying the movements and numbers of melanophores (pigment cells) associated with the skin grafts, both autoplastic and homoplastic transplantations were used.

MATERIALS AND METHODS

The primary animal used in these investigations has been *Triturus viridescens viridescens* Rafinesque (vermillion spotted newt), now known as *Dimictylus viridescens*. The newts were mainly collected from streams at Deer Creek near Union Town, Pennsylvania. The experimental animals were kept in properly labeled individual six-inch finger bowls with 100 cc of tap water at room temperature. Following a transplant being made the animals were placed on wet toweling paper for twenty-four to thirty hours before being returned to finger bowls with tap water. The water was changed three times per week. Animals were fed small cubes of pork kidney three times a week. Five experimental animals were always compared to five non experimental animals or controls.

Transplants were made by excising a four mm square piece of skin the depth of the dermis from the dorsum between the vermillion spots and transferring it to a similar location on the same animal for autotransplants, and to a similar location on a different animal of the same species for homotransplants. When the animal was anesthetized a piece of cloth was saturated with chloral hydrate or chloroform and wrapped around the anterior of the animal. Transplants were observed via a hundred power magnification microscope. This allowed one to see the changes occurring as the autotransplant becomes restructured and the homotransplant becomes reconstructed, deconstructed and then regenerates new host skin in place of the destroyed transplant. One could watch the movements of epidermal and dermal melanophores; and the destruction, reconstruction, and anastomosis of blood vessels. Evaluation of the healing process was measured by tracking the restoration and anastomosis of blood vessels, restoration of circulation at the new site and the transplant and its surrounding areas return to its normal coloration.

RESULTS AND DISCUSSION

All auto transplants became completely and permanently incorporated into the site. However, the healing events listed in materials and methods varied from one animal to another and the variation corresponded with the coloration and number and distribution of melanophores. Homo transplants never became permanently incorporated into the new site on the new host animal. However, the transplant in some animals would reach a period of appearing normal, but would soon begin to deteriorate. When there was an increase in melanophores the processes involved in the deterioration of the transplant were delayed up to two days. When the deterioration began, the first thing observed was an extreme swelling of the blood vessels of the transplant followed by cessation of circulation in the transplant. After circulation ceased complete deterioration followed accompanied by acute loss of color in the transplant. And, the host regenerated skin at the site of the destroyed transplant. In the case of autotransplants, with an increase in melanophores, the regenerative processes may be reduced up to two days. In a separate experiment changes in the color of the transplant were checked with a photometer. The results corresponded to the microscopic observations of melanin in each melanocyte.

In addition to photoprotection other functions have been reported for melanin: thermoregulation, antibiotic, chelating and free radical sink [1-3]. Furthermore, it has also been reported that melanin acts as a scavenger of reactive oxygen species generated by UV; thus, protecting cells and tissues from the toxic effects of free radicals in the area of tissue repair during the regenerative process and in response to pathogens [4-8]. Melanin results from a series of oxidations of tyrosine. Tyrosine is a non-essential amino acid which has been in existence almost as long as life has and as soon as the appropriate enzymes came into existence melanin, too, became part of living systems. It is a component of almost every living system. Whenever tissue is injured usually some form of melanin appears near the injury. This is not only true for animals, but for plants as well. Most of us have seen the dark pigment appear when a banana, apple plum, potato, and other fruits are injured. Yellow skin bananas with dark yellow spots on them are eight times more effective in enhancing the property of white blood cells than the green skin version [9].

During the healing process of a wound on the human skin as well as other animals, a dark ring can be observed surrounding the wound. The dark ring is the result of an increase in the amount of melanin in each melanocyte. If a potato or apple is cut, they too will become darkened in the area of the cut. This darkness is caused by melanin which is formed outside of a cell structure. In the case of the human skin, the melanocytes do not increase, but melanin is increased by ultraviolet radiation or other catalyst removing sulfhydryl group (SH), which activates the enzyme tyrosinase that catalyzes the oxidation of tyrosine to form dihydroxyphenylalanine (DOPA) and with additional oxidations forms more melanin.

During the formation of melanin, melanogenesis, some protection is given to the tissue. While conducting research at Kent State University [10], and in subsequent years, it was discovered that an increase in melanophores/melanin in the area of the wound reduced its healing time in Triturus viridescens viridescenes (Rafinesque). It also took a shorter time for autoplastic transplants of skin to achieve normality when there was a higher density of melanophores and therefore, a higher concentration of melanin in and around the transplant.

In the case of homoplastic skin, transplants increased the density of melanophores and melanin delayed the dedifferentiation or the destruction process of the transplant in comparison with those transplants with fewer melanophores and therefore, less melanin. This was determined by observations of the amount of melanin at various stages in the vascular reaction. The amount of melanin present in pigmented cells surrounding the transplanted skin was measured photometrically. The more melanin presents the longer the graft persisted and wound healing was enhanced [11].

CONCLUSION

In those early years, the evidence of how these pigment cells might influence wound healing and skin transplantation was not known. However, it is now known that in the human species there are melanin units composed of one melanocyte, approximately thirty-six keratinocytes and one Langerhans cell. These cells participate in the immune process, therefore, serving as the first line of defense since they are concentrated in the skin, the outer barrier of the organism. There is no evidence that pre-mammalian species do not have defined keratinocytes and Langerhans cells. Even though keratinocytes and Langerhans cells do not have the same embryonic site or origin as pigment cells, which are the neural crest, perhaps the pigment cells in pre-mammalian species perform some of the same functions as the keratinocytes and Langerhans cells.

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