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Multifunctional Merkel cells: Their roles in electromagnetic reception, finger-print formation, Reiki, epigenetic inheritance and hair form

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SUMMARY

Merkel cells are located in glabrous and hairy skin and in some mucosa. They are characterized by dense-core secretory granules and cytoskeletal filaments. They are attached to neighboring keratinocytes by desmosomes and contain melanosomes similar to keratinocytes. They are excitable cells in close contact with sensory nerve endings but their function is still unclear. In this review, following roles are attributed for the first time to the Merkel cells: (1) melanosomes in Merkel cells may be involved in mammalian magnetoreception. In this model melanosome as a biological magnetite is connected by cytoskeletal filaments to mechanically gated ion channels embedded in the Merkel cell membrane. The movement of melanosome with the changing electromagnetic field may open ion channels directly producing a receptor potential that can be transmitted to brain via sensory neurons. (2) Merkel cells may be involved in finger-print formation: Merkel cells in glabrous skin are located at the base of the epidermal ridges the type of which defines the finger-print pattern. Finger-print formation starts at the 10th week of pregnancy after the arrival of Merkel cells. Keratinocyte proliferation and the buckling process observed in the basal layer of epidermis resulting in the epidermal ridges may be controlled and formed by Merkel cells. (3) Brain–Merkel cell connection is bi-directional and Merkel cells not only absorb but also radiate the electromagnetic frequencies. Hence, efferent aspects of the palmar and plantar Merkel nerve endings may form the basis of the biofield modalities such as Reiki, therapeutic touch and telekinesis. (4) Adaptive geographic variations such as skin color, craniofacial morphology and hair form result from interactions between environmental factors and epigenetic inheritance system. While environmental factors produce modifications in the body, they simultaneously induce epigenetic modifications in the oocytes and in this way adaptive changes could be passed onto the next generations. Merkel cells are multisensorial cells that can receive almost all environmental stimuli including electromagnetic and ultraviolet radiations, temperature, humidity and food type and they seem to transfer the environmental information to oocytes by affecting nuclear receptors in oocytes. (5) Hair form is categorized as straight, wavy and spiral. Merkel cells found at the bulge region of hair follicles may determine the hair form with their different paracrine secretions related to hair cycle producing variations between populations. In conclusion, Merkel cells are multifunctional cells which may close the gap between orthodox medicine and complementary medicine such as acupuncture and Reiki.

Introduction

Merkel cells are neuroendocrine cells found in hairy skin, glabrous skin, and ectoderm-derived mucosa such as mouth, lips and nose [1]. In glabrous skin, Merkel cells are always located on the epidermal ridges in close contact with myelinated nerve fibers [2]. In hair follicles, Merkel cells are located in the bulge, an area that corresponds to the reservoir of stem cells, and are rarely associated with nerve endings [3]. In hairy skin, Merkel cells are found in thickened parts of the epidermis between hair follicles, the so-called "touch dome" [4]. Various nerve fibers innervate Merkel cells within the touch dome, but stimulation of touch domes housing Merkel cells does not produce a conscious sensation [5]. Merkel cells also exist in the epithelia of oral and nasal mucosa but some of them are not connected to nerve fibers and play a role within the epithelium as isolated cells [6]. Merkel cells are linked to adjacent keratinocytes by desmosomes and attached to the basement membrane by hemidesmosomes [3]. Microvilli are present on the cell surface and interdigitate with the surrounding epidermal cells [2]. Furthermore, melanosomes have been described inside the cytoplasm of Merkel cells [7]. Their cytoplasm also contains a cytoskeleton of intermediate filaments (cytokeratin CK20) that are more loosely distributed than in keratinocytes and extend into spine-like protrusions [8].

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Merkel cells synthesize numerous neuropeptides contained in dense-core secretory granules located in the cytoplasm apposed to the nerve terminals [1]. After stimulation of the Merkel cells, dense-core granules release their neuropeptides by classical exocytosis, but the stimulation required for this phenomenon has not been clearly identified [9]. The peptides presumably act as neurotransmitters, neuromodulators, or mediators, acting on sensory nerve endings and serving either a trophic role on keratinocytes or some unknown endocrine function [1]. Both Merkel cells and neurons are excitable cells, but the information that may be transmitted has not been clearly elucidated [10]. Merkel cell–neurite complexes and their localization in touch-sensitive areas led to the suggestion that they are mechanoreceptors [11], but studies disagree about the dependence of epidermal touch sensitivity on Merkel cells [12]. While the structure of the Merkel cell is well established, their function is still unclear. The numerous peptides they synthesize and release may allow them to communicate with many cells other than neurons, and they may play an important role in human physiology and biology. The purpose of the present review is to shed light on the possible functions of these least-known cells of the skin.

Role of Merkel cells in electromagnetic reception

Many animals have a magnetic sense which they may use in navigation, but almost nothing is known of the detailed cellular structures and processes by which magnetic fields are detected and encoded by receptor cells for transmission to the brain [13]. The discovery that crystals of the mineral magnetite (Fe_3O_4) underlie the ability of magnetotactic bacteria to swim along magnetic field lines [14] inspired searches for magnetite in diverse animals. Magnetite particles suitable for use in magnetic field detection have been subsequently discovered in a wide range of animals [15] and identified within candidate magnetoreceptor cells in the nose of fish [16]; and in the orbital and nasal cavity of birds [17]. The magnetite-containing structures found in birds and fish do not seem to be identical, implying that the respective magnetite-based receptors might differ in their general characteristics in other organisms [18]. Most magnetite isolated from animals has been in the form of single-domain crystals similar to those found in magnetotactic bacteria [19]. Such crystals are minute, permanently magnetized bar magnets that twist into alignment with the earth's magnetic field if allowed to rotate freely [20]. Magnetite-based receptors could provide information on direction as well as on intensity. Primary magnetoreceptors have not yet been identified with certainty in any mammals [18]; behavioral evidence, however, indicates an involvement of magnetite in the mammalian magnetoreception [16,21–24]. It has been proposed that freely moving magnetite particles could exist in eukaryote cells if a suitably sized single-domain magnetite grain is held in a membrane but is free to align to the earth magnetic field [25]. If this were linked to mechanically-activated ion channels it could signal the direction of the magnetic field when certain orientations were presented. These suggestions uniquely identify a single-domain magnetite-based, polarity-sensitive receptor as providing an essential component for detecting the magnetic field in mammals. A particularly simple arrangement is the coupling of one end of a magnetosome to mechanically-activated ion channels in a suitable receptor cell [13]. As yet, the location of the receptor cells containing magnetite in mammals is unknown and the structure of the receptor cells also remains to be determined. Since magnetic fields pass freely through biological tissue, magnetoreceptors need not contact the external environment and might plausibly be located nearly anywhere within the body of a mammal [20]. Magnetoreceptors might also be tiny and dispersed throughout a large volume of tissue, so that no obvious organ or structure devoted to magnetoreception necessarily exists [26].

Magnetic information mediated by tiny magnets is an attractive idea, therefore we have looked for the existence of a magnetic material of biogenic origin in mammals. The involvement of the dark polymer melanin as a biogenic magnetite has been proposed for magnetoreception previously [27]. Melanin is kept in membrane-bound organelles called melanosomes in cytoplasm of certain cells. Melanosomes have paramagnetic centers [27,28] with a negative electric charge [29], and they move to the cell center during exposure to magnetic fields [30]. The above reasons make melanosomes very suitable for magnetoreception in mammals. On the other hand, large particles include multiple domains with their magnetic moments largely canceling each other; particles in the range between 1.2 μm and 0.05 μm consist of a single-domain and have a stable magnetic moment, acting as tiny permanent magnets [18]. Therefore, about 1-μm diameter of single-domain magnetite seems to be highly suitable for the reception of magnetic field [31]. Melanosomes are organelles found in a wide variety of cells and exhibit a range of different shapes: spheres of up to approximately 1 μm diameters and ellipsoids with lengths of up to approximately 2 μm and varying aspect ratios [32]. The size of melanosomes is also consistent with a melanosome-based magnetoreception mechanism.

A few transferred melanosomes have been described inside the cytoplasm of Merkel cells. They are not produced in the Merkel cell, but are taken from the melanocytes as in keratinocytes [7]. We now offer a novel mechanism for the mammalian magnetite-based magnetoreception based on melanosomes in Merkel cells. Our interdisciplinary analysis of melanosomes in the Merkel cells offers a promising system and neurophysiological approach to this complex problem. Only at a first glance, the melanosomes might resemble the magnetosomes of bacteria, which are single-domain magnetite crystals [33,34]. For the transduction process in Merkel cells, a melanosome as a solid permanent magnet could rotate like a compass needle with the changing magnetic field and induce the primary mechanosensory processes by this torque [25,31]. Depending on the orientation and strength of the external magnetic field, melanosomes can exert forces on the membrane and activate certain mechanosensitive ion channels increasing the flux of ions into the cell. Gating these channels will alter the membrane potential and produce graduated receptor potentials that can be transformed to frequency-encoded action potentials and transmitted to brain via sensory neurons. Alternatively, external magnetic fields may cause expansion or contraction of the melanosomes in an orientation-specific manner, relaying the signal via cytoskeleton and initiating a neural response. Therefore, melanosomes and the association of cytoskeletons (possibly cytokeratin CK20) in Merkel cells constitute a fine system to sense the change in magnetic field and to trigger the signal transduction. This magnetoreceptor system may function like a sensitive biological magnetometer, with special structural features standing for the encoding field intensity and inclination as well. So far, this hypothetic structure could not be described down to the subcellular level of any sensory system. Since this magnetoreception system including melanosomes and Merkel nerve endings are present in all mammals, we believe that our suggestion is a realistic candidate for the magnetoreception mechanism for mammals. We previously reported that exposure to electromagnetic radiation from cellular telephones affects Merkel cells leading to their exocytotic activity [35]. In that study, motion of melanosomes located within the cytoplasm of Merkel cells should open the channels and produce a membrane potential. The ability of Merkel cells to release their neurosecretory granules following exposure to electromagnetic radiation supports our present view that Merkel cells are electromagnetic receptor cells.

Little is known about the parts of the brain where the respective information is processed. In rodents, a study identified the superior colliculus as a site of neural activity caused by magnetic stimulation [36], whereas in humans, insula, anterior cingulate and bilateral hippocampus/caudate areas have been implicated as the brain structures involved in processing magnetic information [37]. Merkel cell–brain connection may form the basis of acupuncture [38] and Merkel cell's ability to perceive electromagnetic fields also suggests possible mechanisms for hazardous effects of electromagnetic field in mammals [39].

Role of Merkel cells in finger-print formation

On the palmar surfaces of the hands and plantar surfaces of the feet there are numerous fine epidermal ridges which form regular but complex patterns called fingerprints. Finger-print patterns are encoded at the interface between dermis and epidermis, therefore the pattern cannot be destroyed by superficial skin injuries [40]. Although most fingerprints can be classified as one of three types – arches, loops, or whorls – there is great individual variation in detail, so great indeed that no two people have identical patterns, not even monozygotic twins. The major individual variations in finger-print patterns are largely under genetic control, but they have so far remained inexplicable on any simple scheme of inheritance. In spite of comprehensive knowledge, to date no commonly accepted mechanism for finger-print formation exists. The crucial events for human finger-print formation start at the 10th week of pregnancy when the embryo has a size of just 80 mm [40]. It is observed starting from the 10th week that the basal layer of the epidermis begins to appear slightly undulated. These undulations become quickly more pronounced and form folds of the epidermis into the dermis [41]. These folds are called primary epidermal ridges. The pattern of the primary ridges already defines the future surface finger-print pattern. Therefore, if we want to understand how finger-print patterns form we need to understand how the primary ridges arise.

The primary epidermal ridges arise as proliferations of the basal layer cells [40]. However, it is not at all obvious how cell proliferations can be organized in a way that they give rise to ridges. Reviewing the literature and existing models, we think that Merkel cells are the most likely candidate for the physical process that creates fingerprints and we hypothesize that the epidermal ridge pattern is established as the result of a buckling process guided and formed by Merkel cells acting on the basal layer of the epidermis. In glabrous (palmar and plantar) skin, Merkel cells are located in the basal layer of the epidermis [2]. Clusters of up to 10 Merkel nerve endings are found at the base of the epidermal ridges near the penetration of the sweat gland ducts [42]. The cytoskeleton of the Merkel cells is connected with keratinocytes by desmosomes, and they give further structural support by hemidesmosomes that attach to the basal lamina [2]. Therefore, Merkel cells have physical properties to form undulations in epidermis. It is also plausible that the Merkel cells secrete trophic factors for intense keratinocyte proliferation observed in the basal layer just prior to primary ridge development. After proliferation in the basal layer, buckling toward the dermis occurs by the guidance of Merkel cells. So Merkel cells may completely shape the ridge system and form finger-print pattern.

Referring to this hypothesis we can suggest the following scenario of ridge development: Merkel cells appear on the fingertips and in certain palmar and plantar areas at around the seventh embryonic week in humans [1]. At about the 10th week, differential growth is observed in the basal layer of the epidermis. Merkel cells lead to keratinocyte proliferation and buckling; and primary ridges are formed as the result of these processes. So, we can say that general ridge pattern depends on the function of Merkel cells. The theory presented here provides for the first time a consistent picture how the observed finger-print patterns are produced. Our hypothesis could be confirmed by showing the absence or dysfunction of Merkel cells in patients with congenital absence of fingerprints [43] or in cancer patients loosing fingerprints after chemotherapy [44].

Role of Merkel cells in biofield modalities such as Reiki, therapeutic touch and telekinesis

While specific frequencies of electromagnetic radiation can be absorbed by the body, electromagnetic fields are also produced in the body due to movement or rotation of charged particles such as protons, electrons and ions [45]. So the humans not only absorb but also radiate the electromagnetic frequencies [46]. Biofield therapies such as therapeutic touch (hands-off) and Reiki (hands-on therapies) which have been used to reduce pain, facilitate healing and promote health claim to base their mechanism of action upon modulating energy fields [47]. Efferent aspects of Merkel cell–neurite complexes in glabrous (palmar and plantar) skin seem to play a key role in such biofield modalities. The structural evidence observed in those Merkel cell–neurite complexes supports this view as follows: within glabrous skin, Merkel cells form "touch spots" in the basal layer of the epidermis. Touch spots are innervated by nerve fibers and Merkel cells connect the glabrous skin to the brain through these afferent fibers [48]. Melanosomes and neurone-like properties enable Merkel cells to participate in the electromagnetic perception through interactions with nerve fibers. Conversely, the brain can affect the functions of Merkel cells in an efferent manner since the glutamatergic components present in Merkel cells are more specific to postsynaptic elements than pre-synaptic ones [49,50]. Moreover, mitochondria and other vesicles from the Golgi apparatus found in neurons apposed to Merkel cells, and on the opposite side, presence of a superficial cytoplasm with a Golgi complex and clear vesicles in Merkel cells can be considered as the evidence for two different secretory pathways, the first involving neurotransmitter release from the axons and the second involving mediators of the neuroendocrine pathway from the Merkel cells [51]. Therefore the possibility that Merkel cells are not only the trigger of the neuronal activity but also the target of sensory neurones in an efferent manner is possible. So we can say that the brain–Merkel cell connection is bi-directional [52,53] and Merkel cells not only seem to be electromagnetic receptor cells where applied electromagnetic fields act on the body, but they also seem to be cells through which the efferent signals pass outside the glabrous skin which can be used in biofield modalities such as Reiki, therapeutic touch and telekinesis.

As for the functions of Merkel cells, earthing is another aspect which must be considered. The surface of the earth possesses a limitless and continuously renewed supply of free or mobile electrons as a consequence of a global atmospheric electron circuit [54] and it is suggested that barefoot or hand contact with the earth (earthing or grounding) promotes health by stimulating the migration of charges into the body [55]. The beneficial effects of earthing may be a result of direct earth connection with palmar and plantar Merkel nerve endings which enables both diurnal electrical rhythms and free electrons to flow from the earth to the body [56]. Wearing shoes with insulating soles has disconnected most people from the earth's electrical rhythms and free electrons [54]. In situations where going barefoot on the earth is impractical, putting hands (palms) on earth as most people do 80 times a day in Turkey (with a continuous plantar contact on earth for 60 min) provides a basis that restores and maintains natural electrical contact between the human body and the earth.

In utero functions of Merkel cells

Human fetal adrenal development is characterized by rapid growth, high steroidogenic activity, and a distinct morphology, including a unique cortical compartment known as the fetal adrenal cortex. For most of gestation, the predominant fetal zone accounts for 80–90% of the cortical volume and is the primary site of growth and steroidogenesis, producing 100–200 mg/day of the androgenic steroid, dehydroepiandrosterone sulfate (DHEA-S) [57]. We previously published our hypothesis about dependence of the development of fetal hairs and sebaceous glands on fetal adrenal cortex and suggested that the human fetal adrenal cortex produces DHEA-S beginning at around eighth week of gestation in sufficient quantities to influence the growth of fetal (lanugo) hairs and sebaceous glands which begin to develop after the ninth week of gestation [58]. Sebaceous glands form an oily secretion–sebum that mixes with desquamated epidermal cells to form vernix caseosa. Vernix caseosa protects the developing skin from constant exposure to amniotic fluid, and fetal hairs help to hold the vernix caseosa on the skin [59]. Soon after birth, the fetal adrenal zone atrophies, and adrenal androgen production decreases to minimal levels. As a consequence, fetal hairs are shed and sebaceous glands shrink to small structures [60]. Fetal adrenal cortex seems to affect the development of fetal hairs and sebaceous glands, but the mechanism that regulates fetal adrenal androgen production is a key unanswered problem in human adrenal biology [61]. We suggest here that Merkel cells might play a role in the control of fetal adrenal androgen secretion. Merkel cells arise from stem cells of neural crest origin that migrated during the sixth embryonic week in human skin [3]. These Merkel cells with a density of 1700 per mm^2 showed cytoplasmic processes directed towards the basal lamina and extending between neighboring keratinocytes. However, these cells generally disappear at the end of gestation and innervation is necessary for the survival of Merkel cells in postnatal life [62,8]. It has been demonstrated that Merkel cells in the developing skin transiently expressed mRNA for the serotonin transporter indicating an intact and active 5-hydroxytryptamine (5-HT) uptake system [63]. But, Merkel cells themselves are not able to synthesize 5-HT and the source of 5-HT as a substrate for the transporter in Merkel cells is the amniotic fluid, which contains 5-HT transported from the maternal circulation [64]. By expressing the 5-HT transporter, Merkel cells might have a transient role in sensing the 5-HT levels in amniotic fluid [63] and playing a trophic role for the development of fetal adrenal cortex through their endocrine secretions. Receiving or sensing the extracellular 5-HT levels may therefore allow the Merkel cells to modulate the adrenocortical function and thus to protect fetal skin from harmful effects of amniotic fluid during gestation by forming vernix caseosa. The postnatal decrease in 5-HT transporter mRNA and 5-HT uptake might reflect this physiological phenomena [63].

Role of Merkel cells in epigenetic inheritance and biological adaptation

All human groups of present-day are adapted to their ecological niche in various ways. As a result of adaptation, there is a great deal of variation from one geographic region to another in skin color, hair form, craniofacial morphology, stature, body proportions, and a host of less immediately obvious traits [65]. The term adaptation is therefore interpreted to encompass those responses in the phenotype, which are produced by the action of the environment upon a given gene system, and is applied to those responses which improve some function of the organism or population in a specific environment [66–68]. The population variation in skin melanin is a good example of the adaptive responses our species shows to an environmental stress. It is well known that melanin absorbs the harmful ultraviolet rays of the sun and protects the skin [69]. There is a decline in the production and concentration of skin melanin from the southern African countries to the northern Scandinavian countries. The maximum amount of pigmentation (black skin) is found in hot, humid climates, and minimum (white skin) is observed in cooler climates [70]. Geographic variations are therefore due to direct environmental effects which, over many generations, became inherited and inheritance of adaptive changes occurs only if information from the somatic parts is transferred to germ cells [71]. We previously suggested that adaptive geographic variations in humans may result from interactions between environmental factors and epigenetic inheritance system [72]. Epigenetic inheritance system is a genetic regulatory mechanism that allows humans to maintain extraordinarily stable patterns of gene expression over many generations [73,74]. While environmental factors produce modifications in the body, they simultaneously induce epigenetic modifications in the oocytes and these changes are inherited to offspring [72,75,76]. This system is less stable than the genetic system and more sensitive to the environment [77]. This kind of heritable long-term changes is generally labeled biological adaptation. To explain how environmental influences on somatic characters could be transmitted to the next generation, we suggest here that the Merkel cells affect the somatic parts of the organism as well as the oocytes. Multiple locations of Merkel cells throughout the body form a robust system highly sensitive to environment. In this system, Merkel cells receive a wide range of sensations from the external environment and establish extensive communications with other systems including oocytes. We can say that secretory products of Merkel cells liberated into the circulation transfer the environmental information to oocytes by affecting nuclear receptors. Alternatively, neuroendocrine products of Merkel cells may induce melatonin secretion which then produces epigenetic modifications in oocytes by affecting the nuclear melatonin receptors [72,78]. Hence, Merkel cells are environmental sensors of the body and they seem to be the cells upon which environment operates to produce permanent anatomical traits in mammals. Following considerations make it appear likely that Merkel cells are multisensorial cells that can receive almost all environmental stimuli including electromagnetic and ultraviolet rays, temperature, humidity and food type and thus contribute to inheritance of adaptive changes to the next generations.

Merkel cells as a sensor of electromagnetic and ultraviolet radiation

The intensity of the geomagnetic field is highest at the two poles and lowest near the magnetic equator. It is temporally altered by electromagnetic radiation originating in the sun causing daily variations, which lead to slight decrease in magnetic intensity around noon [18]. There is now ample evidence that mammals can perceive magnetic fields in the intensity range of the Earth's magnetic field and even much smaller intensities, e.g., the daily variation of the natural magnetic field [79,80]. The function of Merkel cells as a sensor of electromagnetic radiation was described in the previous sections. As a sensor of ultraviolet radiation, we can say that melanin in Merkel cells play a key role in sensing the degree of ultraviolet radiation. We know that the damage of ultraviolet rays to the skin is inversely proportional to the amount of melanin in the epidermis since the melanin screens ultraviolet penetration. Melanin is produced by melanocytes and the skin of all humans contains the same spatial density of melanocytes, but the activity of melanocytes differs between ethnic groups [69]. Since the number of melanosomes in Merkel cells also shows geographic variations as in keratinocytes [81], it is plausible to suggest that epidermal Merkel cells may transmit the information about the degree of ultraviolet radiation to next generations.

Merkel cells as a sensor of temperature and humidity

The mechanism in which the arterial blood destined for the brain is cooled by venous blood returning from the evaporating surfaces of the scalp and upper respiratory mucosa is called selective brain cooling [82]. Selective brain cooling protects the brain from thermal damage in a long-standing manner by allowing adaptive mechanisms to change the craniofacial morphology appropriate for different environmental conditions [83]. For example, craniofacial features such as thick everted lips, broader nasal cavity and bigger paranasal sinuses that provide more evaporating surfaces seem to be anatomical variations developed in time for an effective selective brain cooling in hot climates. A broad nasal cavity permits maximum surface area of nasal turbinates for cooling the inhaled air, [66] and thick, everted lips tend to radiate more heat and thus cool the brain [65]. Merkel cells in the nose and lips are external receptors that in close contact with the environment assuming both chemical and physical roles [84]. Therefore, Merkel cells scattered throughout the nasal cavity and lips [85], may provide a detection system for environmental temperature and humidity, and may transfer the environmental information to the next generations to produce appropriate craniofacial morphology for different environments.

Merkel cells as a sensor of food type

Maximum bite force data in various human populations reveal impressively high values among the Eskimos [86]. The chewing of the seal skins, frozen food and bones, and the use of the jaws as a 'third hand' or as an all-purpose vise is well documented among various Eskimo populations. These activities require a powerful masticatory apparatus and Eskimo skull is especially adapted to generate and dissipate large vertical biting force. Here, the type of food is an important environmental stressor leading to craniofacial diversity, because hard diet requires more chewing force and time, and it promotes the vertical growth of the mandibular ramus and anterior translocation of the maxilla in Eskimos [86,87]. The oral mucosa covering the hard palate and gingiva withstands heavy mechanical loads during chewing and therefore is called masticatory mucosa. Many Merkel cells are found in the masticatory mucosa [2,88] and they play an important role in monitoring mechanical properties of food. Merkel cells in masticatory mucosa may act as a mechanoelectric transducer transferring the information about food type to offspring and lead to optimum chewing functions in different geographic regions.

Role of Merkel cells in hair form and skin biology

Hair form is an important structure that has enabled man to adapt to life in diverse environmental conditions [69]. Humans who reside in cold climates tend to have straight hair; inhabitants of more moderate climates have wavy hair, and those from hot humid climates have tightly coiled, spiraled, wool-like hair. Tightly coiled spiraled hair tends to facilitate the removal of the heat from the scalp and cooling of the brain while straight hair promotes conservation of heat and warming of the body [83]. Amount of hair on the body also shows marked differences between populations. The people of eastern Asia and Africa tend to have little body hair. In Australian Aborigines however, body hair is well developed and hair form is wavy [65].

Despite the qualitative distinctions that are made, the cause for the variation in hair types is unknown. Merkel cells in hair follicles seem to be involved in the formation of different hair types with their paracrine secretions [89]. In hair follicles, Merkel cells, located in the bulge region that contains stem cells for hair growth and regeneration, are generally not nerve-associated and there exists a relationship between the number and the morphology of Merkel cells in association with the hair cycle. The number of Merkel cells in hair discs increased during the phase of anagen and decreased during catagen and telogen [90]. Therefore, it is reasonable to accept that Merkel cells may produce different hair forms appropriate for different environments with their different paracrine secretions related to hair cycle. Whatever functions they establish and whatever stimuli they receive, we think that females must not epilate the leg hairs as seen on the legs of Mo'nique in Golden Globe 2010 (epilation of hairs may result in cellulite of the skin), and males must not cut the facial hairs (beards).

Skin biology is also different between populations, for example the lipid content and electrical resistance of black epidermis is somewhat higher than white epidermis [91]. Ethnic differences in skin biology may be established by Merkel cells which secrete substances for regulation of epidermal cells in a paracrine fashion leading to the keratinocyte proliferation and skin homeostasis. Numerous cellular contacts between Merkel cells and other epidermal cells allow molecular exchanges, thereby modulating the functions of the skin [92].

In conclusion, Merkel cells are multisensorial cells that can receive almost all environmental information; and multifunctional cells that have the capability of finger-print formation, electromagnetic radiation and formation of vernix caseosa and different hair types. In addition, Merkel cells may close the gap between orthodox medicine and complementary medicine such as acupuncture and Reiki.

Conflicts of interest statement

None declared.

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I dedicate this work to my parents Fatma and Ferhat Irmak and to my wife Zisan Irmak.

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