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Science of Skin: Skin Through the Ages.

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Science of Skin: Skin Through the Ages

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Skin is the boundary between who we are as we present ourselves to the world while acting as the barrier to the insults that we experience in our day-to-day existence[1]. Skin is the largest organ in the body and as such it is critical to the maintenance of our bodies. If we suffer damage to our skin, we can suffer a loss of function, both psychologically and physically[2, 3]. Our skin is like a painter's canvas: we can determine in large part what 'painting' we want the world to see.

To describe our skin as our boundary between ourselves and our environment underestimates how truly dynamic the skin function is. The barrier function of the skin is both dynamic and complex[4]. We have learned that we live, for the most part, in harmony with a large number of bacteria in the environment[5]. Current estimates are such that we believe that we have more bacteria on the parts of our bodies exposed to the environment than we have cells in our bodies[6]. We also have learned that bacteria do not live in isolation. Science has examined bacteria historically a single organism at a time. We are familiar with some of the names of these disease-causing organisms precisely because they lead to disease. The skin is a part of the body where large numbers of bacteria reside and as a result, a balance between the skin and the bacteria is required for normal function of the skin[7]. We also have learned that these bacteria form communities that themselves are in a delicate balance. The awareness that bacteria exist in communities has led to new ways to study these groups and we refer to the collective grouping of bacteria as the "microbiome" or "microbiota". The skin has its own "skin microbiome" where a balance in the skin's environment allows for us to peacefully coexist with these bacteria bodies[8].

Under more detailed examination, we have learned that the skin is composed of multiple layers: epidermis, dermis and 'hypodermis' or subcutaneous fat[9]. The hypodermis or subcutaneous fat is an area where cushioning occurs to prevent damage to the underlying organs of our body, particularly bones and bony prominences. When the hypodermis is insufficient, for example, in patients with inadequate nutrition, these bony prominences can break through the skin resulting in a pressure ulcer[10]. The dermis contains blood vessels and nerves and regulates heat through sweat glands and through blood flow. Blood flow is absent in the epidermis so that regulation by the dermis is critical. The dermis also contributes to our metabolism. However, the primary barrier of our skin is maintained by the epidermis, the outermost layer of the skin. The epidermis consists of multiple layers. The basal layer produces cells that migrate towards the skin surface and subsequently die. The layers between the basal layer and the outermost layer, the 'stratum corneum' have viable cells. Like the dermis, these cells perform metabolic functions, particularly related to vitamin D metabolism, but the cells also produce sufficient acid to reduce the pH of the skin's surface to approximately 5.0[11]. This mild acidity forms the 'acid mantle' that acts as the first line of defense against bacteria causing disease.

The stratum corneum is thin, no thicker than a sheet of paper, and is composed exclusively of dead cells. These cells are refreshed by the migration of living epidermal cells from the basal layer to the surface. While the cells of the stratum corneum may be dead, their function remains and their biochemistry is critical to maintaining normal fluid levels in the skin. A protein, filaggrin, determines normal fluidity of the epidermis. Technologies surrounding enhancement of fluid retention in the skin focus on providing water absorption properties similar to filaggrin. It is the stratum corneum that is covered with the bacteria of the skin microbiome. Fluid balance in the skin is important to skin health. Moisture associated skin damage, incontinence associated dermatitis, venous leg ulcers and diabetic leg ulcers are all disease expressions where the fluid balance has been lost and there is too much fluid. This imbalance can allow for infections to occur from organisms within the 'skin microbiome'.

Detailed knowledge of the members of the skin microbiome has allowed us to develop and to continue to develop technologies that can be used to help reduce the risk of infection when the skin barrier is breached as part of current medical therapy. Antiseptics are agents whose composition reflects years of development so that these agents can reduce the number of bacteria on the skin while avoiding damage to the skin in the form of irritation. Proper antisepsis requires proper technique and proper antiseptics require an in-depth understanding of the science of skin[12]. Reducing the number of bacteria on the skin is known to reduce the risk of infection following any type of disruption of the skin barrier: surgery or the placement of vascular catheters or direct therapy of an underlying disease become possible with a high degree of clinical comfort. The living portion of the epidermis that lies beneath the stratum corneum has the capacity to monitor for bacteria invasion and to respond with mediators that destroy bacteria. There is a natural immune system within the living portion of the epidermis referred to as the 'innate immune system'. It is our first line of defense against bacterial infection and this protection is yet another reflection of the dynamic nature of our skin.

Our genetics and our lifestyles help to determine the health of our skin. We are more familiar today with genetics and our genetic makeup more than ever before. At the beginning of this century the entire DNA sequence of a human being was completed[13]. Prior to that event, it was considered impossible to achieve such a goal. Not only has this goal been achieved, but we see the results of this technology moving through our society. It is possible for anyone willing to provide saliva or blood samples to learn about their genetic makeup and what it could mean to their life's journey[14]. The skin reflects these genetic changes, although genetic change in the skin is more often associated with disease than with function. Genetic changes can be subtle or dramatic and complex as well, requiring years before they are expressed clinically and become apparent both to the patient and to the caregivers.

The reason our unique genetic composition may take years to express reflects the dynamic nature of the skin over long timeframes. There can be changes in skin function that we can observe over a matter of minutes, over hours, over days, over weeks or over years. The skin is a dynamic organ over all of these timeframes and it varies over all these time frames in a continuous fashion. The ability to understand the interplay of who we are as given by our genetic makeup and the dynamic responses of our skin to the world around us constitutes the science of skin. Reducing the number of bacteria on the skin prior to surgery or over the entire time course of treatment with a vascular or other invasive device that engages the skin as part of therapy requires a dynamic understanding of the skin's responses[15]. The understanding of the science of skin is critical in order to allow for the successful development of technologies that require the successful interaction of the technology with the living skin.

It is often stated that we live in a "toxic" environment. We often choose to take part in actions that can result in negative effects on our health, sometimes knowingly but often without our knowledge. On a minute-to-minute basis we can experience psychological stress: we're late for an important event as one example. There is a stress hormone, cortisol, that rises with stress. The skin has chemical systems-that also produce and modify cortisol levels. If we are stressed our skin responds. If our skin is stressed, for example, suffering a sunburn, then our cortisol levels change and our psychological response can change. Our skin and our minds are connected in ways we might never have appreciated before.

The environmental stress from sunlight need not result in sunburn. However, extended exposure to sunlight results in detrimental changes to our skin that can take years to appreciate. Damaged skin will be less resilient because of an accelerated loss of a particular protein-elastin. We lose elastin naturally so that even with the best efforts there are changes that occur over time that present science and technology cannot seem to prevent.

Aging over a period of decades will result in a series of well-documented, if not well-understood, changes to the skin. The epidermis has a natural 'wave-like' structure that flattens over the years. As considered earlier, the dermis lies beneath the epidermis and this layer is critically involved in heat loss or heat gain. Temperature management in the skin is handled by blood vessels and sweat glands. It may be the case that we blush when we are embarrassed but it is these same blood vessels that dilate in response to physiological stimuli as well. When fluid is lost due to sweat, it is released on the epidermis. There the stratum corneum serves its most critical function: fluid management. If a device or material is attached to intact skin then fluid accumulation can occur to varying degrees depending on our individual physiology. Excess fluid can result in moisture associated skin damage. The design of materials that adhere to the skin must reflect an understanding of this part of the science of skin.

The thinned layer of the dermis and the epidermis that occurs with ageing means that there is an increased risk of harm when a device incorporating an adhesive is attached to the skin[16]. The "device" has a range of possibilities: it can be a sensor, a wound dressing, a cover over the exit site of a vascular catheter, the material used to secure an endotracheal tube, a dressing applied to a chronic ulcer or the material used to fix a catheter in place being used for a specific reason, e.g., providing anesthesia directly into the spinal cord. In all these situations there must be a balance between performance of the adhesive – and therefore the 'device' – and the maintenance of the skin's integrity.

As we age and our skin barrier becomes weaker, we have an increased risk for damage due to removal of the device when the adhesive is too aggressive. Medical adhesive related skin injury or "MARSI" has become a recognizable entity[17]. Maceration due to too much fluid is one possibility. However, more commonly, most skin injury occurs when the adhesive containing device is removed from the skin. When this process occurs, tension blisters, skin stripping or skin tears can all occur. These adverse events reflect the dynamic nature of the skin's interaction with adhesives. Skin cells are bound to one another through protein linkages. When an adhesive attaches to the skin it can react with the skin in ways that result in the strength of the interaction of the adhesive and the skin being greater than the strength of the bond between and among cells. When this reality is achieved, removal of the adhesive will result in skin removal with the cells attached to the adhesive. The 'adhesive' strength of the bond of the adhesive to the skin exceeds the 'cohesive' strength of the cells binding to each other. This situation requires an in depth understanding of the technology of adhesives to prevent or reduce in frequency.

Aging and the increased risk of damage due to adhesives represents one end of the age spectrum. At the opposite end are infants, newborns and in particular premature infants. While infants that are born at the typical gestational age of 40 weeks rapidly develop nearly adult-like skin characteristics, premature infants are at an increased risk for MARSI because their skin is incompletely developed. In some of these most vulnerable of patients, MARSI can require surgical repair of the wound that occurs. In some others, infection can occur, the result of an imbalance between the skin and the bacteria of the skin microbiome. Recognizing the changes in the skin that occur over a person's lifespan also is part of the science of skin that results in different technological solutions for a changing environment.

Genetics, age and environment are critical factors that we all share in the journey that our skin takes through life. Additional considerations result from a variety of diseases that may not be directed at the skin but are reflected by the skin's condition nonetheless[18, 19]. Diabetes mellitus is a disease that continues to increase in the number of affected patients worldwide. The disease is chronic but we all maintain our desire to be part of our society and technologies have evolved to help make this possible. It is now technically feasible to monitor glucose levels directly and continuously, although current technologies require a break in the skin's integrity to make this occur. As a consequence of having an elevated glucose blood level, automated or patient-controlled pumps can provide insulin to maintain a nearly normal glucose blood level[20]. These devices require adhesion to the skin. Patients, however, want more. They want these devices to more fully integrate into their lives and they want designs that will pronounce less dramatically to the world that they require these devices. Integrating who we are with devices attached to the skin is currently and will become an even greater part of our skin health story.

Clearly, the skin is a dynamic organ, reflecting who we are in the presence or absence of a disease. Our ability to have our skin maintain its integrity and ability to act as a barrier against damage and infection depends on our age, genetics, environment exposures and underlying clinical condition. It may be the case that as we look for medical care in the near future we may be able to state not only our age but we may develop the capacity to describe the "functional" age of our skin since so much of modern therapy depends on the ability to adhere to skin.