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Regeneration of Human Scar Tissue with Topical Iodine: A Preliminary Report—Part 2

David M. Derry, MD, PhD*

*332-425 Simcoe Street, Victoria B.C. Canada, V8V 4T3
Contact: dderry@shaw.ca

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Abstract. This paper adds (to Part 1) details of human scar regeneration with topical iodine and examines hair's role, epithelial layer transparency, and structural units. Topical iodine starts regeneration within a few days. Hair's main new activity is the ability to move freely and on its own to all parts of the regeneration field within its reach. Hairs, within regenerating areas and with help from nerves and arrector pili muscles, are capable of reaching cells accurately anywhere within its reach in any direction. At the same time, follicles appear to make regenate material and transport it along to hair ends by unknown mechanisms which mimic sebum transport from sebaceous glands attached to follicles. Regenate material on hairs is discontinuous; and hair may use touch, electrical signals, regenate material, and coding to signal other cells. Globular regenate material is not discussed here.

Classic studies emphasize the epithelial layer's importance in covering wounds immediately and its important functions in regeneration landmarks. This epithelium is quite transparent in photographs; the transparency affects photographic results. Camera angles perpendicular to skin surfaces allow observation in detail of structures inside the body or below the surface of epithelial layers. This method can be described as an *in vivo* microscopy for watching human tissue activity. Cellular structure is not apparent in most regenerating tissue (which is understandable) as camera magnifications are inadequate to examine cells microscopically. There are much larger structural "units" with unknown function. Hair self-amputation is ubiquitous and may be an important part of tissue strengthening and scaffolding. Physical properties, behavior, and reactions with iodine and tissues allow the suggestion that regenate material may be a mix of sebaceous and mucous secretions similar to saliva. Theoretical aspects of these phenomena and treatment potential await other scientists' results.

Keywords. Epithelial • Hair • Human scar • Regenate material • Regeneration • Transparent

Introduction

Early Changes in Wound Healing and Regeneration

Tsoni[1] and Clarke[2] review limb regeneration and wound healing literature. There are a number of well established observations related to early overgrowth of special epithelium before healing or regeneration can take place. If this epithelial layer is removed, regeneration processes and healing stop.

Importance of Hair

In a previous paper, time-lapse-type photography of regenerating scars suggested that hair is important to regeneration.[3] Hair moves in any direction to any locality within its reach, and transports white material (called regenate material) to different cells in regenerating areas. Hair also self-amputates. At times, together with its follicle, a hair stub disappears only to reappear later and re-grow back to normal lengths.

Potential for Cell Signaling of Different Types by Hair

Cell signaling is being intensely studied, and it is possible that hairs have one or more such systems built into their activities. Touch and electrical stimuli could be significant. Regenate material traveling to hair ends by unknown mechanisms is discontinuous and could be used for signaling.

Epithelial Growth over Wound

Epithelial cells grow rapidly over wounds and provide a continuous cover. This layer is biochemically different from the dermis and has important effects on tissues underneath it. It is innervated early but does not need innervation for regeneration to occur, whereas nerves are essential for remaining tissues to regenerate. Epithelial layers send chemical signals to underlying cells that help blastema cell formation and dedifferentiation—two key events in salamander regeneration.[1]

Epithelial Layer Transparency

Photographs of regenerating tissue indicate that epithelial layers growing over wounds are transparent. No other explanation seems plausible. This is important because epithelial layer transparency alters photographic results.

Methods

Lugol's Solution Applications and Plastic Wrap

Methods used were described previously but quite simple.[3] If topical iodine in the form of Lugol's solution (iodine in water) is applied daily to human scars and then covered with plastic wrap, regeneration begins within two or three days. Regeneration stops gradually over a few days when iodine applications are stopped.

If iodine applications are stopped, a normal adult scar forms that is compatible with the current state of regeneration. At the terminal stages of regeneration, adult scars either do not form or are slower forming. There may be final regeneration stages in which formation of adult scars is not the best alternative.

Regeneration appears to make new tissues compatible with the age of surrounding tissues. That is, if surrounding tissues are wrinkled from age new healed areas will usually have wrinkles. There is no evidence yet of rejuvenation (younger tissue made) from topical iodine. In addition, loose skin anywhere on the body (from losing weight after a period of obesity) is not affected by iodine regeneration. So far, it appears that iodine-induced regeneration requires scar tissue of some form to be initiated.

Cameras: Nikon Cool Pix

Five different Nikon Cool Pix cameras with mega pixels between 5 and 8 were used to record regeneration progress. Each camera had a zoom lens for magnifications of about 7x; one camera had an enlarging attachment which allowed magnifications up to 20 times. This attachment, however, was awkward because of a fixed stand.

Scars

There are four scars. One is a 50-year-old scar on the face from surgical removal of a mole. Another is an abdominal scar 18cm long opened three times before final closing. (All bowel function was normal for the three years of the present study.) A colostomy scar and a 2.5cm scar on the left wrist complete the list.

Controls

Only internal controls were possible in these experiments and consisted of different types of scars of all sizes and degrees of damage and age. In addition, regeneration was started and stopped repeatedly for variable lengths of time, the longest period being four months.

This paper, like Part 1, documents observations to date on regeneration from topical iodine. Over a three-year period much information has been recorded, but the largest scar still will be regenerating for at least another year or two. This large scar is continuing to yield important data on regeneration. The smaller wrist scar is in terminal stages of regeneration and has been purposely slowed and intermittently stopped to extract as much information as possible before regeneration ends. When that happens, no further information will be available.

Results

Hair and Regenate Material

Where possible the author has used wrist regenerating fields for illustration. This includes the two coordinating centers in the photographs both for size comparison (they are 5mm apart) and for reader orientation. Without these stationary markers, it is easy to be visually confused.

There are two types of regenate material, a white snow-like and a globular form. Only the first type will be examined here; the globular form will be discussed later. All references to regenate material in this paper are to the white snow-like type. (See Derry.[3]) Regenate material under plastic wrap is seen at all sites in one or both forms. Photographs suggest that one major source of regenate material is hair follicles. The newly formed regenate material moves up hair ends by unknown mechanisms for distribution to tissues.

Hair and Units

During the recording of hair activities in regeneration fields it was helpful to identify each frequently seen hair by number. Hair follicles and coordinating centers do not change locations. Figure 1 shows wrist regenerating areas immediately adjacent to the two coordinating centers. The centers are 5mm apart and straddle the radial artery, which is not visible in the picture but comes down from the left upper corner to pass between the two centers and then on to the left side of the hand (the picture's right side). Hairs sitting on the radial artery have small oscillating movements noticeable at their ends corresponding to heart beats. There is always a palpable but invisible ridge between coordinating centers throughout regeneration (3 years). As this is a left wrist photograph, fingers (distal) are right and the body (proximal) is left. Hair #1 is identified as originating in a follicle about 2-3mm to the left and 1mm down from the upper center. In Figure 1, hair #1 is on the left side curving downwards and further towards the left. The shortness and the blunt end indicate that it has self-amputated earlier to about one-third of its normal length.

Figure 1. Photograph of the wrist scar area. There are two coordinating centers; both store iodine. A number of hairs all deliver regenate material to tissues. The tissue non-uniformity displayed is partly related to epithelial layer transparency as well as live tissue complexity. Free iodine in Lugol's solution stains the epithelial layer a brown color seen throughout the picture. Areas where unusual details appear are areas where visualization through transparent epithelial layers is possible. The self-amputated and shortened hair #1 is seen curving to the left on the left side and services a unit on that side. The longer hair coming down from the top is hair #2. Hair #2 tapers to a very thin almost invisible hair towards its end. It has regenate material on it as do other hairs on the left side. On the upper right, two hairs are servicing "units." As it is 5mm between the two coordinating centers, this unit is about 2mm in diameter. This is 10 times normal cell size. Most details change within minutes to an hour.

The self-amputated hair #1 in Figure 1 is "servicing" (delivering regenate material and/or information to) either a large cell or a larger structure named here as a "unit." Units seem to be a part of regeneration. There are a number of "units" between the two coordinating centers, two of which are being serviced by hairs near the upper coordinating center. At hair #1's follicle there is suggestive evidence of some white regenate material.

Although it is difficult to see where every hair ends, all the ends seem to have specific sites in "units" they reach and touch. It is remarkable how, over a week, a hair will go to many locations of regenerating fields but when it returns to this unit site, for example, it goes to the same place within the unit. This suggests that the mechanisms controlling hair movement, such as nerves and arrector pili muscles, have an ability to place hair ends accurately. Sometimes two or more hair ends will congregate within one unit. Hairs can also disappear under the skin surface and then surface again later at the same site. Regenate material can be seen on hairs.

Figure 2. Photograph of the wrist coordinating centers with self-amputated hair #1 "servicing" the upper coordinating center. The small hair to the left of the upper coordinating center may be touching hair #1. During the time the hairs touch, regenate material and possibly signals are exchanged between them.

Hair Self-Amputation

Self-amputation is a constant ubiquitous finding in regeneration. Hairs cut themselves off usually less than half way to the end. This can be followed by regrowth back to normal or self-amputation down further even to follicles leaving only a hair stub. Hairs self-amputated at varying lengths, including one centrally placed stub, are well illustrated in Figure #5.

All hairs with blunt ends in regenerating fields are likely to be previously self-amputated, and the long, tapering, disappearing hairs are intact. The hair self-amputation cycle repeats many times. But the cycle differs from hair to hair and may be geared to tissue needs. Hair #1, the first observed and photographed, self-amputated about a third of the way up the fiber and stayed like that for a week or two. It then self-amputated again to a stub at the follicle. (See Derry.[3]) Other hairs may self-amputate once and then grow back out to normal length. Even the hair stubs function.

Hair #1 is about one-third of its normal length in Figures 1 and 2. Figure 1 shows it servicing a unit on the left. In Figure 2, it services the upper coordinating center. Tissue sites where stubs have disappeared are visited by other hair ends, which appear to service the sites even without the visible presence of any hair or follicle. In spite of disappearing from our view or seeming non-functional, stubs and areas where hair was before disappearing are still part of regeneration.

Figure 3. Photograph of the wrist area regeneration demonstrating regenate material gathering at the hair follicle areas prior to transport up the hair. There is regenate material on the hair on the right, and there are many examples of regenate material on other hairs. The brown stain is only in the epithelial layer; there is no visual evidence that tissues stain below epithelial layers. There are two examples of double hair follicles, down in the right corner and up in the left corner. Each hair can go its own way.

Hair #1 and Inter-Hair Touching

In Figure 2, hair #1 is turned around and while "servicing" the upper wrist coordinating center is in contact with a small hair that appears in both Figures 2 and 5. This touching of two hairs may often involve transfer of information or regenate material between the hairs. The transfer of regenate material between hairs is a common occurrence. Throughout much of Figure 2 large structures called "units" are seen whose function is unknown but are found throughout regeneration. None of these units stay looking the same for even a few minutes.

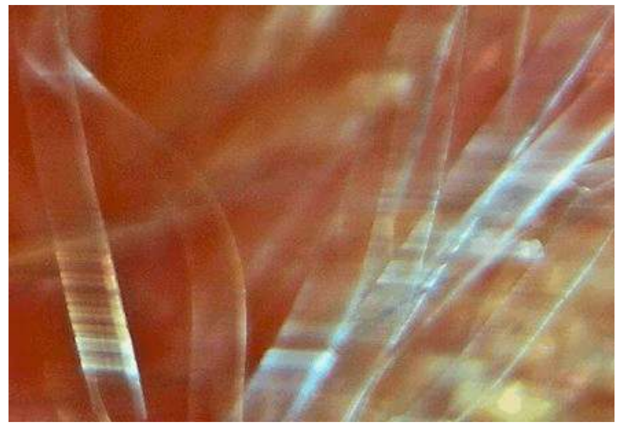

Figure 4. Regenate material moving along hairs is discontinuous. This is seen more clearly when hairs with regenate material on them are moved and photographed at the same time. The patterns are similar to bar codes seen in the grocery stores.

Figure 3, the wrist regenerating field, is a simpler picture in order to show at least one possible source of regenate material. This area is above the two coordinating centers and illustrates a number of points. The brown stain is free iodine within epithelial cells. The pieces of epithelium are alive and functioning since the dose of topical iodine was correct. There does not appear to be any brown stain deeper than the epithelial layer. Hair follicles readily take up iodine stain or are found near pieces of epithelial tissue containing iodine.

The follicle in the lower center of Figure 3 shows regenate material around it. Other hairs show regenate material transporting along hair fibers. In this picture stained epithelial tissue continues as part of regeneration until used up, especially if covered. But as mentioned in the first paper,[3] free iodine evaporation is rapid in the early stages after staining.

Figure 3 contains two examples (right lower corner and left upper corner) of follicles with two hairs coming out of one follicle. As we see from the two hairs in the left upper corner, individual hairs can go to their own destinations. Only occasionally do pairs of hairs travel together to the same site.

The previous paper[3] mentioned the discontinuity of regenate material on hair. In Figure 3 the hair coming from the left center shows discontinuous regenate material. Regenate material on hairs is difficult to photograph (these are at camera magnification limits). Yet seen through the camera screen, discontinuity is quite clear. Regenate material often looks like dots and dashes. But when regenate material on hair is photographed while hair is moving, we get a different picture of regenate material's discontinuity. There is a similarity to the bar coding widely used in society. This more clearly demonstrates discontinuity.

Epithelial Covering, Camera Angle, and Transparency

From many decades of research we know that epithelial cell layers rapidly covering wounds is important for initiating and sustaining regeneration in salamanders. Many photographs of regeneration with unusual visual results suggested the idea that epithelial layers must be transparent. Only transparency would explain the visual findings.

Figure 5. Photograph of wrist regeneration field at an angle from the left to reveal the coordinating centers, the underside and thickness of epithelial layers, and the effects of epithelial layer transparency on the results. The text describes the four epithelial layers that have formed here to protect the regenerating field. Excess iodine was purposely applied to kill, by apoptosis, epithelial layer cells. Also, the wrap was removed to allow tissues to dry. The epithelial layer is thin, perhaps only one or two cells thick. The tissues started to lift and peel as soon as the underlying skin wound was protected by a new epithelial layer. Note on the left where the amount of iodine present at the periphery of the apoptotic stain remains attached to underlying tissue. The amount of iodine at the periphery was at a sub-apoptotic level. During the process, the coordinating centers, although storing iodine, do not seem to be altered.

Epithelial Layer Transparency

Regenerating tissues handle excess iodine by killing surface epithelial cells and reacting with released proteins (apoptosis).[3] With experience, it is possible to add excess iodine to the point that only the epithelial layer dies. This is shown in Figures 5 and 6.

Figure 6. This shows the appearance of the dead peeling epithelium seen in Figure 5 from a perpendicular angle; this photograph was taken before Figure 5. The two coordinating centers are at the top above the peeling epithelial layer. Outlines of underlying tissue are seen. This result suggests a new epithelium formed on the dying and peeling epithelium. See text for explanation. Thus, new epithelial layers form above and below dead epithelium to continuously protect regenerating tissues.

After applying excess Lugol's solution, the author removed the plastic wraps and allowed the tissues to dry. Waiting until the epithelial layer started lifting, the author peeled some of it away to see the wrist coordinating centers. (See Figure 5, the two black dots filled with stored iodine). Figure 6 is a photograph of the same epithelial layer before the layer has lifted enough to clear the coordinating centers. (Figure 6 was taken before Figure 5.) The two dark dots up in the left corner of Figure 6 are stored iodine in the two centers still sitting on top of the peeling epithelial layer.

Figure 7. Angled photograph of wrist regenerating area (similar to angle in Figure 5). The two coordinating centers are in the middle. Most of the whole area appears flat, uninteresting, and divided into large square areas resembling farmers' fields as seen from an airplane. There is no indication of the underlying complex structures and regeneration activity seen in perpendicular photographs. The upper coordinating center is filled with iodine; the lower center is below it. One hair is almost covered in regenate material and shows white in the photograph in the middle center. The area of the right lower quadrant of this photograph (approximately between the date stamp and the lower center) is seen in Figure 8, but with a perpendicular view. The differences are striking.

Four Epithelial Layers in One Picture (Figure 5)

On the basis of the epithelial cell layer's behavior and staining characteristics, together with the assumptions that it is transparent and continuously trying to prevent by all means exposure of the regenerating field, we can suggest where the epithelial layers are in Figure 5. Literature emphasizes that epithelial layers cover wounds within hours and continue covering wounds until healing finishes. If the epithelial layer is removed, regeneration stops. The photograph in Figure 5 was taken at an acute angle from the left in order to see more clearly both coordinating centers and the underside of the peeling epithelial layer. (The camera angle is similar to the one used for Figure 7.) One unusual finding in Figure 5 is that only areas sharply in focus are those with no epithelium on them (the two coordinating centers, the underside of the peeling dead epithelium, and the hairs).

First Epithelial Layer. At the bottom, closest to live tissue, mostly white opaque tissue appears after removing part of the peeling dead epithelium. This skin tissue has been rapidly covered with a new epithelial layer because the original layer has died from excess iodine and is peeling off. Because of the angle no details of tissue structure are evident in the white opaque area to confirm the presence of the transparent epithelial layer.

Second Example of Epithelial Layer. The original epithelial layer on the wound has died by apoptosis after excess iodine application. It appears to be one or two cell layers thick. The excess iodine is being carried away to slough off dead tissue as the plastic wrap is removed.

Figure 8. Photograph of activities and structures seen through the epithelial layer in the area above the date stamp in Figure 7. The appearance of the units is constantly changing. The units are generally 10 times bigger than cells and their function is unknown. The long straight brown lines are previously laid down self-amputated hairs forming part of regenerating tissue.

Third Epithelial Layer (on the Left of the Photograph). This layer on the left was part of the original epithelial layer, most of which is now stained brown and peeling in the middle. But because there was less iodine at peripheral parts of the stain, these peripheral epithelial cells did not die. This part of the epithelial layer on the left is lightly stained and still attached to the underlying skin tissue. Even looking at this small piece of the field, there is little to see because of the acute camera angle. As the bigger original layer peels off it rips away from the layer on the left.

Fourth Epithelial Layer. As the original layer started to die, signals to cover the dying regenerating layer again with fresh epithelial cells were sent out. Thus, the brown blurry area on the right side is another epithelial layer overlying the dead layer. In this manner regenerating scars are constantly protected from exposure to the atmosphere by epithelial layer activities.

A perpendicular picture of the peeling epithelial layer in Figure 5 is shown in Figure 6. The two coordinating centers are up in the left corner still on top of the epithelial layer. (The photograph for Figure 6 was taken before that of Figure 5.) We see in Figure 5 the centers both came through the dead peeling layer easily.

Figure 9. Photograph of the lower half of the large 18cm abdominal scar. The crossing "fingers" of regeneration are seen at intervals down the scar. The picture is taken from above and perpendicular to the scar surface. The area immediately above the date stamp is the umbilicus.

In Figure 6 we start to see some details of the underlying structures but they are not as good as in Figure 8, which is a picture of the same area at another time. The peeling epithelial layer in Figure 6 was dead and had more iodine in it than necessary. Since it was not as transparent as live tissue, we get the inferior image in Figure 6.

In Figure 5 the underside of the peeling epithelial layer shows units more clearly, as we would expect. Thus, with the presence of four epithelial layers the regenerating surface is protected.

Figure 10. Photograph of same lower half of the abdominal scar taken two minutes after Figure 9 as shown on date and time stamps. This is exactly the same scar and the same area, only the angle of the photograph in this picture is acute rather than perpendicular to the scar. The difference between the two photos is striking. This confirms that there is a transparent layer of epithelial tissue overlying the scar. This layer is essentially invisible to the naked eye but not to the camera.

Macroscopic Views of Regenerating Area to Appreciate Transparency

Figure 7 is a photograph taken from the left at an angle and at low magnification of wrist regenerating areas. Note the two wrist coordinating centers with some iodine in them in the center. Most of the field consists of large square areas (5mm between the two centers) that are reminiscent of farmers' fields seen from an airplane. Regeneration is proceeding under this layer but we are not aware of it.

Transparency from Perpendicular Angle to Tissue. Figure 8 is a photograph of the same "flat farmers' fields" area above the date stamp in Figure 7. The picture is taken perpendicular to the area. The amount of detail is not only overwhelming but continues to change within minutes.

Transparency on a Larger Scale. To show again epithelial layer transparency in a different location, Figures 9 and 10 are two photographs of the 18cm abdominal scar below the umbilicus that were taken two minutes apart (as seen on the date-time stamps). Figure 9 is photographed perpendicular to the bottom of the scar. The presence of "finger-like" projections on both sides (mentioned previously[3]) is easily seen. The size of the crossing fingers varies. The large ripples in the tissue in and around the date-time stamp are from regeneration over the umbilical area. Half-way up the picture on the left side, there is a small black object which may be small globular regenate material.

Same Photograph Two Minutes Later at an Angle. The photograph in Figure 10 is zoomed in further to eliminate umbilical focusing interference. But more importantly, it was taken two minutes after Figure 9. On closer view, the small dark object on the left may indeed be small globular regenate material. But shock comes from scar area appearance being so different. It is now covered in smooth, slightly stained material. This is the transparent epithelial layer covering the lower scar area.

Discussion

Hair

Hair may have multiple roles to play in regeneration. If this proves to be so, then it will bring to the attention of researchers something we have largely ignored. Perhaps hair has even more functions than are sketched here. Iodine stimulates all regeneration hair growth. Clinically, hair loss in women can be restored with adequate iodine supplementation.

Cell Signaling

It is reasonable to think that hairs with the type of controlled mobility observed in this case report would have cell signaling capabilities. Touch and electrical signals seem to be probable. Signaling via regenate material is more complex but possible. First, the regenate material by itself could signal. Only regenate material's discontinuous appearance makes possible— as in Figure 4—a suggestion of bar coding. All of this is speculative, but in light of the results these are reasonable questions to ask.

Epithelial Transparency

The literature emphasizes that the epithelial layers growing immediately over a new wound are biochemically different from normal dermis, and that they play major roles in regeneration outcome. This type of epithelial layer also synthesizes proteins which are specific to the layer. Removal of this layer stops regeneration. The layer can phagocytose wound debris, and by histolysis of underlying cells aid dedifferentiation of cells (in salamanders).

The first detectable change starting regeneration is covering of the wound with this special epithelium. The epithelial cells rapidly migrate inwards to cover wounds without mitosis or DNA synthesis.[1] Once cells meet in the middle they become innervated, but epithelial innervation is not essential for regeneration. It is thought that this epithelium sends important signals to underlying tissues to start regeneration. The main point regarding transparency is that it alters our view of tissues.

The photograph in Figure 4 is blurry where there are epithelial layers. Whereas hair, coordinating centers, and the underside of the peeling epithelial layer are the only places where there are no epithelial layers—thus, they are all in sharp focus. When the camera is shot at an angle, the site of probable epithelial layers is demonstrated by blurriness and opaqueness.

Units and Cells

Although tissue subdivisions which are considerably larger than cells have been referred to as "units," there is no real understanding of what they are or how they function. They are mostly formed from even larger nondescript structures and subdivided by hairs as they fall across the units (this is followed by hair self-amputation). If these structures function as one unit, then there is no consistent evidence of intracellular organelles. Normal body cells are around 0.2mm, while the units seen here are often 10 times that size.

Human skin becomes rougher and bumpy with age, and cameras at maximum magnification (3-20 times) have narrow depths of field.[7] This leads to sections being out of focus, and in many photographs this is true. But repeated photographs of the same skin in a live person show different results. The reason for this difference, from the photographs presented here, appears to be epithelial layer transparency. When looking directly at skin, we in fact are looking below the surface of the epithelial layer—something artists have appreciated for centuries. Skin tissue observed with cameras during regeneration can be classified as a form of *in vivo* microscopy; almost everything in these pictures is alive.

Possible Chemical Nature of Regenate Material

Since regenate material sources seem to be hair follicles, there are two relevant excretions from the skin. Sebum from sebaceous glands attached to hair follicles contains exclusively lipid products such as cholesterol, squalene, fatty acids, and waxes. Sebum is secreted by a type of cell disintegration called holocrine secretion. Normally, sebum secreted onto hair is transported up the hair the same way regenate material is transported during regeneration.

During regeneration of scars under plastic wrap, moisture accumulates with white regenate material. This moisture could be water soluble mucins. The available moisture would increase mucin secretion by surface epithelial mucous cells. The parotid and submaxillary glands have both sebaceous and mucous cell secretions. Oral cavities have numerous separate sebaceous glands.[4] Saliva, as a final mix, has both water and lipid solubility properties.[6]

Mucins are huge water soluble complex proteins containing thousands of amino acids. These molecules, with molecular weights sometimes in the millions, have highly glycosylated protein cores with multiple oligosaccharides and complex tertiary structures. The sebum, on the other hand, is a lipid mixture. In addition, epidermal cells undergo sebaceous transformation under stress.[4] The regenate material on skin scar regeneration fields is likely a mix from these two sources.[4][5][6][8]

Conclusion

One cannot help but be impressed with regeneration's almost unlimited flexibility. Even fetal development does not have this property. If completely regenerated scars are opened again, it seems certain that iodine applications would start the regeneration process once more. There appear to be no age limits to regeneration's effectiveness. If a new wound occurs in regenerating scars, again the process adapts and begins healing both scars in a coordinated fashion. Only the arrival of finished normal tissue stops regeneration (from what has been observed so far). Regeneration is one of Nature's most complex, mysterious, and magnificent accomplishments. Unraveling how and why it works will take many years. In the meantime, because treatment procedures using this approach are harmless, if care is taken, physicians and patients can use this treatment to their benefit while scientists work to solve regeneration's mysteries.

References

1. Tsoni, P.A.: *Limb Regeneration. Developmental Biology* (Developmental and cell biology series). Edited by P.W. Barlow, J.B. Bard, P.B. Green, and D.L. Kirk, Cambridge University Press, 1996.
2. Clark, R.A.: Wound repair. In *The Molecular and Cellular Biology of Wound Repair*, 2nd edition. Edited by R.A. Clarke, New York, Plenum Press, 1995, pp. 3-35.
3. Derry, D.M.: Regeneration of human scar tissue with topical iodine: A preliminary report—part 1 (three years). *Thyroid Science*, 3(6):CR1-9, 2008.
4. Montagna, W.: An introduction to sebaceous glands. *J. Investigative Dermatol.*, 62:120-123, 1974.
5. Perez-Vilar, J. and Mabolo, R.: Gel-forming mucins. Notions from *in vitro* studies. *Histol. Histopathol.*, 22: 455-464, 2007.
6. Lagow, E., DeSouza, M.M., and Carson, D.D.: Mammalian reproductive tract mucins. *Human Reproduction Update*, 5:280-292, 1999.
7. Ashcroft, G.S., Horan, M.A., and Ferguson, M.W.: The effects of ageing on cutaneous wound healing in mammals. *J. Anat.*, 187:1-26, 1995.
8. Smith, K.R. and Thiboutot, D.M.: Sebaceous gland lipids: friend or foe? *J. Lipid Res.*, 49:271-281, 2008.