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JANUARY 1959
The calculated minimum force/unit area necessary to permanently suspend particles is shown to be very closely related in actual experience to the physical measurement of yield value with the Brookfield Viscometer.

Yield Value is associated with "Plastic" flow behavior. This is shown to be a very rare occurrence in "solutions" of the most widely used natural and synthetic gums. Of all the polymer "solutions" evaluated, carboxy vinyl polymer is unique in exhibiting high yield value at low concentrations.

BIBLIOGRAPHY


MUCOPOLYSACCHARIDES IN HUMAN EPIDERMIS

By Peter Fuchs, M.D., Ph.D.*

Presented October 1, 1958, New York Chapter, New York City

During the past few years our knowledge of the development and chemical composition of the human epidermis has progressed rapidly (1). In spite of great advances made in this field, we still do not understand some of the most common anomalies of the skin surface which are of great importance to dermatologists and cosmeticians alike. Therefore, the discovery of a new epidermal component is of considerable interest, because it may explain the origin of certain abnormalities. The present paper deals with such a component of the human epidermis, the mucopolysaccharides.

Actually, the compounds are not at all "new." What we witness today is not their discovery, but their rediscovery. Thirty years ago, at a time when the role of the mucopolysaccharides in skin physiology was entirely unknown, Rothman (2) with remarkable foresight, called attention to works of several German authors. These works reported the extraction from human and animal skin of a mucin-like substance which was soluble in alkali and could be precipitated with acetic acid. A large portion of

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This mucin is essentially identical with the mucopolysaccharides found in the connective tissue of the body, such as those in cartilage, nerve, and connective tissue of the eye.
MUCOPOLYSACCHARIDES IN HUMAN EPIDERMIS

This material was believed to have originated from the epidermal cells. This belief was based on the following finding: whole skin (epidermis + dermis) yielded considerably higher amounts of this mucin-like material than skin denuded of its epidermis.

In the ensuing years more and more evidence began to accumulate indicating that in some epidermal structures and locations and under certain conditions, mucopolysaccharides appeared to be consistently present. The evidence was based on histochemical observations and on direct chemical analyses.

It is beyond the scope of this paper to discuss the specialized and often rather involved techniques which are used for the histochemical identification of mucopolysaccharides. For our purposes it will be sufficient to state that none of the histochemical methods are in themselves specific for mucopolysaccharides. However, when certain technical details are followed and when the effects of certain enzymes on the suspected material are observed, it is possible to conclude with a high degree of probability that the substance in question is indeed a mucopolysaccharide. One of the most characteristic staining features of mucopolysaccharides is their metachromasia, i.e., their ability to stain in a color different from the dry solution itself. For details the reader is referred to reviews in the field (3, 4, 5).

Among epidermal structures, metachromatic material was found by Swedish scientists in some growing structures, such as the root matrix (6), in the root sheaths of the hair, in epidermal hyperplasia, in precancerous and cancerous lesions (7, 8). More recently Montagna et al. published beautiful pictures, showing metachromasia in the external sheath of the hair follicles. Of great interest is also the intense metachromasia of the papillae of growing hair follicles (9).

With the use of metachromasia and of other histochemical techniques, mucopolysaccharides were shown in the intercellular spaces of normal (9a) and pathologic epidermis (10) and in psoriatic epidermis (11, 12) and horny layer (13).

CHEMICAL ANALYSES

Hydrolysis of epidermal structures and extracts sets free the component elements of mucopolysaccharides. Building stones, such as hemoxane, hexasulfonic acid, and uronic acid can be qualitatively and quantitatively analyzed. A mucoprotein was isolated from extracts of psoriatic scales by Roe (13); a similar substance could be extracted from scales of a patient with syphilitic dermatitis as well (14). Hexasulfone, protein-bound hexasulfonic acid were found in homogenates of normal epidermis in higher concentrations than in blood serum (10); these compounds also occurred in hydrolyzed scales and scale extracts of patients with psoriasis (11).
In our own work we extracted callus and psoriatic scales with water and determined the glucosamine content of the extracts before and after hydrolysis (15). Both callus and psoriatic horny layers yielded significant amounts of glucosamine; in extracts of psoriatic scales the amounts were often higher than in callus. After hydrolysis the glucosamine content of extracts of callus remained constant or rose slightly, while hydrolyzed extracts of psoriatic scales showed a large increase in glucosamine (Fig. 1).

Glucosamine has also been detected in sweat, a finding which requires confirmation (16).

In summary, it may be stated that mucopolysaccharides are regular components of many growing epidermal structures. The exact localization, distribution and nature of this material still remains to be elucidated. Montagna’s suggestion that it is chondroitin sulfate B fits well with the available evidence (9).

**Possible Role of Epidermal Mucopolysaccharides**

What is the function of these substances in epidermal tissues? We can only speculate at present. In other tissues some of their functions are to bind water and to hold the cells together in a cementing matrix (17). The maintenance of cementing and water-binding properties is also essential for the normal appearance and functioning of the horny layer (1, 18).
However, at present there is no evidence that mucopolysaccharides perform such functions in the fur coat; our own preliminary experiments have not yielded conclusive data.

A much more likely role has been suggested by Sylven (19). He noted that metachromasia in the rat skin fluctuates with the skin cycle. The greatest concentration occurred during periods of intensive growth, the lowest amounts in the resting stage. Sylven believed that the metachromatic substance may act as a sulfate donor and help in building keratinous material. Recently, this theory received further support when it was found that sheep could synthesize cysteine in the hair follicles from sulfate (20).

In rat follicles the uptake of labeled sulfate coincided with metachromasia (21). None of these studies conclusively prove that mucopolysaccharides are essential for the synthesis of keratin. However, in the past few years evidence has also been obtained from clinical observations of hair loss in which a disturbed mucopolysaccharide metabolism may play a role.

Hair Loss and Mucopolysaccharides

There are three recently discovered types of hair loss which may be caused by anomalous mucopolysaccharide metabolism. Two of these conditions, baldness in hypervitaminosis A and from anticoagulants, are man-made, iatrogenic; the third, wigs, is of unknown origin.

1. Alopecia from Chronic Vitamin Intoxication

About half of the patients suffering from the effects of prolonged excessive intake of vitamin A lost their hair to varying extents (22). The hair loss was always reversible after discontinuation of vitamin A. Unfortunately, in these cases no histochemical studies for mucous material have been carried out; not even biopsies were performed, and therefore the histologic features of this condition are unknown. Nevertheless, if one is inclined to assume that a disturbance in the hypothetical mucopolysaccharide-keratin metabolic chain may be responsible for this type of hair loss, it is possible that excessive vitamin A causes mucous transformation of the keratinizing cells of the hair follicles as shown in the classic studies of Fall and Mellanby (23) and confirmed by Weiss and James (24) and by Lasnitzki and Greedberg (24a). Local application of excessive vitamin A to the rat skin also induces changes suggestive of mucous degeneration (25).

Vitamin A also increases the uptake of sulfate from labeled sulfate in the mucopolysaccharides of rat skin (26) and in rabbit hair (27).

2. Alopecia from Heparin and Heparinoids

Administration of heparin and a variety of synthetic anticoagulants leads to reversible hair loss in a high percentage of cases (28, 29, 30). All these compounds are sulfated derivatives of various polysaccharides.
Again the hair loss is reversible. The histologic and histochemical features of these conditions are unknown. The most likely assumption is that the anticoagulants act as competitive inhibitors of the natural mucopolysaccharides, thus preventing the synthesis of keratin.

3. *Alsopaca mucinosa*

This rare type of hair loss was discovered by Pinkus in 1957 (31). It is characterized by the accumulation of mucous material in the hair follicles and sebaceous glands. Under the name "mucophanerosis sebaglandularis et intracuticularis," it was later described by Braun-Falco (32) who distinguished two varieties: the "idiopathic" kind (i.e. of unknown origin) and a type associated with various other skin diseases.

In summary, there is strong evidence to favor the assumption that mucopolysaccharides are essential for the synthesis of keratin. It is premature to decide whether they act as "building stones," "precursors" or as "donors of active sulfur" (33).

**SUMMARY**

Mucopolysaccharides occur in a variety of epidermal structures, especially during intense proliferation. Their presence has been demonstrated with histochemical and direct chemical methods. Experimental and clinical studies indicate that these compounds are probably essential for the synthesis of normal keratin. Hair loss from excessive intake of vitamin A, from heparin and heparinoids and in the condition called *Alsopaca mucinosa*, may be due to disturbances in the hypothetical mucopolysaccharide-keratin metabolic chain.

**Acknowledgment:** The assistance of the Chesebrough-Pond's Inc. is gratefully acknowledged.

**Addendum**

After completion of this manuscript, Hirsch and Helwig presented histochemical and physicochemical studies on an epidermal tumor, called syringochondroma, where the epidermal cells produce a metachromatic material which is transformed into cartilage (*Am. Acad. Dermatol.*, Dec., 1958). Our own recent work suggests that in pathologic horny layers a highly resistant mucopolysaccharide complex is retained in the scales.

**References**

THE COSMETIC ARTS IN ANCIENT EGYPT

By George R. Hughes*

Presented June 11, 1936, Chicago Chapter

Since I do not know very much about cosmetics either ancient or modern, I was initially somewhat appalled at the prospect of learning enough to impart anything of interest and value to you, a group of specialists in cosmetic chemistry. To find out what constitutes the words "cosmetic" and "chemistry" when put together placed upon me a view of the material available from ancient Egypt, I looked up the words in the dictionary.

"Cosmetic" derives from the Greek term χυμος meaning "having power to arrange, skilled in decorating," and the adjective in turn derives from

* Associate Professor of Zoology, University of Chicago, Chicago, Ill., Field Director of Epigraphic Survey, Louas, Egypt.
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![Figure 1](image_url)

Figure 1.—Glucosamine in aqueous extracts of powdered callus and scales of patients with psoriatic and xeroderma pigmentosum before and after acid hydrolysis.

Glucosamine has also been detected in sweat, a finding which requires confirmation (16).

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**POSSIBLE ROLE OF EPIDERMAL MUCOPOLYSACCHARIDES**

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There are three recently discovered types of hair loss which may be caused by anomalous mucopolysaccharide metabolism. Two of these conditions, baldness in hypervitaminosis A and from anticoagulants, are man-made, iatrogenic; the third, *Alpaca mutton*, is of unknown origin.

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**Appendix**

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