The skin is composed of two distinct areas — the epidermis and the dermis. The epidermis consists of many layers of dead skin that are supported by the dermis. The dermis is a three-dimensional network of collagen fibers and elastin fibers surrounded by gel-like material called the ground substance. This determines the stability of the skin. The dermis accounts for most qualities we consider cosmetic, i.e., the appearance of the skin. These include a moist, plump appearance and tautness. The aging process is therefore considered skin that is less taut, less moist, less plump, and in some areas, sagging along lines that are flexed (also known as wrinkles). If a preparation could increase the turgor and firmness of the dermis, it would be a real "treatment" cosmetic.

We know that the ground substance is composed of mucopolysaccharides, noncollagen proteins, and water. Mucopolysaccharides are also known as glycosaminoglycans. The purpose of this paper is to review the structures, formation, and role of these mucopolysaccharides as well as the benefits of applying hydrolyzed mucopolysaccharides to the skin.

Structure of Mucopolysaccharides

Mucopolysaccharides found in the dermis consist of hyaluronic acid, chondroitin sulfates, and dermatan sulfate. Their structures are as follows:

![Mucopolysaccharides structures](image)

Mucopolysaccharides are composed of hexosamines (on the right) and hexuronic acids (on the left). The molecular weight of hyaluronic acid is several million while those of chondroitin sulfates B and dermatan sulfate is about 40,000.

The half-life of hyaluronic acid is 2-4 days, that of chondroitin sulfate and dermatan sulfate is 7-10 days. This indicates that mucopolysaccharides turn over in the body very rapidly compared to collagen or elastin.

Production

Mucopolysaccharides are produced in the body by the well-known route from glucose (see Figure 1). During dermis aging, the amount of hyaluronic acid decreases from 70% to 30%, while chondroitin sulfate decreases from 20% to about 7%. This results in a parallel decrease in the water content as well as turgor of the dermis.

![Figure 1: Production of mucopolysaccharides](image)
Research into the role of mucopolysaccharides in the dermis is a relatively new field. In 1935, "The mention of mucopolysaccharides to collagen biochemists was likely to evoke a hurt or scornful reaction. 10 We now know that the functions of mucopolysaccharides are very important.

The most important function of mucopolysaccharides is as a binding agent for water. Hyaluronic acid can hold from 3 to 4.5 liters of water per gram. The gel-like structure of water with mucopolysaccharides fills the space between collagen fibers. This is essential for maintaining the proper degree of turgor pressure and plasticity of the tissue. 11

The structure of mucopolysaccharides also allows them to regulate the water content of connective tissues, restrict other solutes, and act as a sieve for passage of large molecules. 12 The anionic nature of these polymers also enables them to function as ion-exchange regulators. Hyaluronic acid seems to be most often located in the interstitial collagen network. 13 Dermatan sulfate is more often associated with collagen fibers. 14

The other major function of mucopolysaccharides involves their relation to collagen. Mucopolysaccharides restrict the conversion of soluble collagen to insoluble collagen. 15 On aging, the ratio of mucopolysaccharides to collagen decreases. 16 Mucopolysaccharides also function as lubricants for collagen fibers.

We know that the collagen fibers have a sixth of mucopolysaccharides surrounding them. While we reconstitute these fibers free of mucopolysaccharides, they are much more rigid. 17 Dermatan sulfate has not been isolated from the dermis without causing collagen degradation. Finally, dermattan sulfate has been found to inhibit maturation of collagen into its insoluble form, thus increasing the amount of insoluble collagen degraded by "collagenase." 18

Studies of Cosmetic Applications

It is obvious from examining the role mucopolysaccharides play in the dermis that increasing or replacing the diminishing amounts present will yield skin with more moisture and more soluble collagen, and the collagen fibers will be more flexible. This is the goal of treatment cosmetics.

In one study, two groups of rats were treated with a solution of mucopolysaccharides and a blank saline solution. The results indicated that mucopolysaccharides had no effect on the skin of the rats. 19 This result was scientifically expected, since the molecular weight is high and penetration was not expected.

In the early 1960s, Laboratory Vey, Inc., Geneva, Italy made commercially available a hydrolyzed mucopolysaccharide called talasamin (CTPA, adopted name). Hydrolyzed Mucopolysaccharide, abbreviated HMP. This precursor (the smallest mucopolysaccharide molecule) was developed for the purpose of permitting absorption of the metabolic precursor of mucopolysaccharides through the skin. Tulasamin is a 100% active white crystalline powder that is readily soluble in water. A 5% solution has a pH of 1.3-4.5 and a rotation after 1 hr of +46° (±0.5). It is nontoxic and nonrespiring.

When HMP was tested in a manner similar to the test run for mucopolysaccharides, the results indicated rapid repair of induced ulcers. 20

A second study was performed with HMPs to see if they would stimulate the biosynthesis of mucopolysaccharides. This was done by radioactive tracing of HMPs in a cosmetic cream. The results showed the increase of mucopolysaccharides in the dermis, increased hydration of the dermis, and greater elasticity of the skin. 21

Rialdi reported on a controlled study of the applicasion to rats of a cosmetic cream containing HMPs. The study measured the following properties:

- Skin moisturization — measuring the water content of the skin.
- Skin turgor — measuring the rapidity of cicatrization of a standard trauma.
- Skin elasticity — measuring the tensile strength of the scar tissue of a standard trauma.

Thirty rats were treated twice daily with a cream containing HMPs, while thirty rats were treated using the same cream without HMPs. The rats were broken into three groups, and tests were run at 12, 24, and 30-day intervals.

The results are listed below:

- **Moisturization:**
  - % increase H2O = H2O treated - H2O control x 100 / H2O control
  - % increase cicatization = Cicat. treated - Cicat. control x 100 / Cicat. control

- **Turgor:**
  - (1) 10 days: 21%  
  - (2) 20 days: 30%  
  - (3) 30 days: 35%

- **Elasticity:**
  - % increase tensile strength = F treated - F control / F control
  - (1) 10 days: 16%  
  - (2) 20 days: 19.5%  
  - (3) 30 days: 23%

The second part of this study was done with 25 women. They applied the control cream once a day for 30 days to the cheeks, backs of hands, and legs. They applied the control cream to one side and a blank to the other side. They were not aware of the contents of either cream.

After 30 days, the women were examined and evaluated by three dermatologists who also were unaware of the contents of the creams or which side was treated with which cream. They evaluated the women for four parameters: general appearance, moisturization, elasticity, and roughness. The results showed improvement from a minimum of 7.6% to a maximum of 41.2%, with the average being 25%. The dermatologists concluded that incorporating HMPs greatly improved overall appearance and moisturization and produced clearly positive results in improving elasticity and roughness. 22

Recently, an independent testing company conducted another double-blind test to confirm the published results. 23 Twenty women applied diluted solutions (0.375% and 1.0%...
### Table I: Moisturizing cream

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>%</th>
<th>CFA Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Xanthia 1:5</td>
<td>5.0</td>
<td>PEG-8 C12–C15 steryl ester</td>
</tr>
<tr>
<td>Nestol</td>
<td>18.0</td>
<td>Glyceryl Tri C16–C18 acids</td>
</tr>
<tr>
<td>Liposolve UD</td>
<td>8.0</td>
<td>Tretinoin</td>
</tr>
<tr>
<td>Elederemasticide</td>
<td>0.02</td>
<td>Thiosulfate hexasulfate anhydrated (and) undecylenyl PEG-5 paraben Unspoilable soy oil</td>
</tr>
<tr>
<td>B Isodronanoic propylene glycol</td>
<td>1.0</td>
<td>Isoceteth-10 ester (and) isosteareth-10 isostearate</td>
</tr>
<tr>
<td>Isonol H</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>45.0</td>
<td></td>
</tr>
<tr>
<td>C Fragranse Iluminina</td>
<td>0.04</td>
<td>Hydrolyzed mucopolysaccharides</td>
</tr>
<tr>
<td>Collagenin</td>
<td>2.0</td>
<td>Soluble collagen</td>
</tr>
<tr>
<td>Water</td>
<td>6.14</td>
<td></td>
</tr>
</tbody>
</table>

Heat A and B to 65°C–70°C. Mix A into B with stirring. Homogenize 10 min, cool to 40°C. Dissolve in water, mix with Collagenin and fragrance. Add C to A and B at 4°C. Stir and cool.

### Table II: Moisturizing tonic

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>%</th>
<th>CFA Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propylene glycol</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>Hydroessential rose</td>
<td>0.015</td>
<td>Rosetil</td>
</tr>
<tr>
<td>Water</td>
<td>87.185</td>
<td></td>
</tr>
<tr>
<td>Denosa</td>
<td>0.03</td>
<td>Glucanase</td>
</tr>
<tr>
<td>Ilastramin</td>
<td>0.2</td>
<td>Hydrolyzed mucopolysaccharides</td>
</tr>
<tr>
<td>Color</td>
<td>u05</td>
<td></td>
</tr>
</tbody>
</table>

Mix the hydroessential rose with the water using a homogenizer until completion of solubility. Mix the remaining ingredients.

### Table III: Moisturizing gel

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>%</th>
<th>CFA Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ilastramin</td>
<td>0.25</td>
<td>Hydrolyzed mucopolysaccharides</td>
</tr>
<tr>
<td>Hydroessential chamomile</td>
<td>0.01</td>
<td>Chamomile oil</td>
</tr>
<tr>
<td>Methyl paraben</td>
<td>0.1</td>
<td>Gelling agent</td>
</tr>
<tr>
<td>Liposolve UD</td>
<td>9.66</td>
<td></td>
</tr>
</tbody>
</table>

Dissolve the hydroessential chamomile in the water with a homogenizer. Add the Ilastramin and methyl paraben and dissolve. Finally, add the Liposolve with stirring. Once the gel has formed, store the mixture using a vacuum.

### Formulations

- **Formulations**
  - For one- to two-week periods, these results showed HMPs to be a very effective and indeed superior treatment for the skin.”

### References


### Footnotes

- David C. Steinberg is manager of technical services for Tri-K Industries, Inc., Westwood, New Jersey. He has been with the company since 1964. Steinberg received a BS in chemistry from Drexel University, Philadelphia, PA, in 1965, and an MBA from Pace University, New York, in 1969. He is a member of the American Chemical Society, the Institute of Food Technologists, and the Society of Cosmetic Chemists.