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THE JOURNAL OF THE SOCIETY OF COSMETIC CHEMISTS

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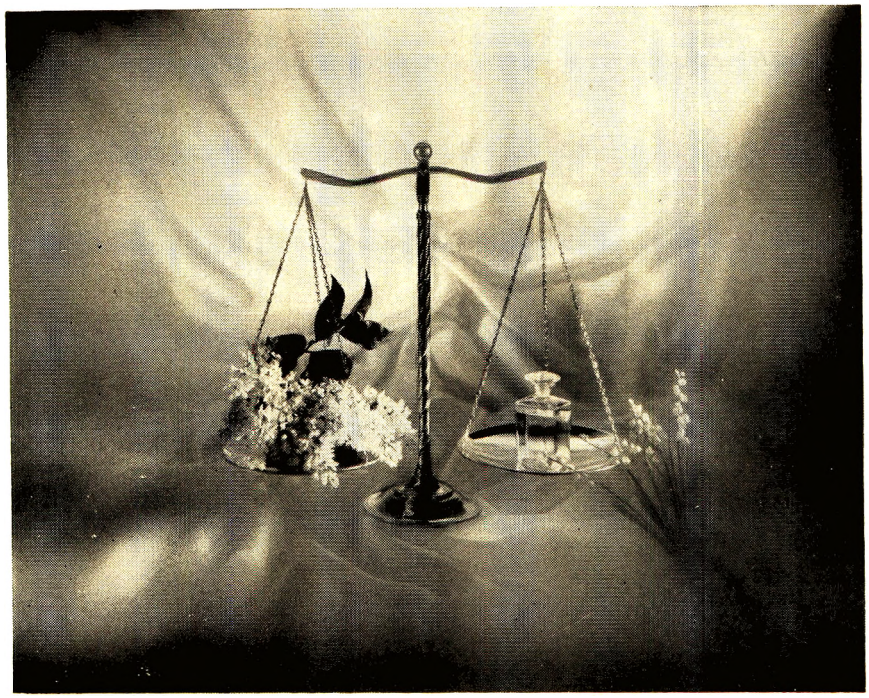

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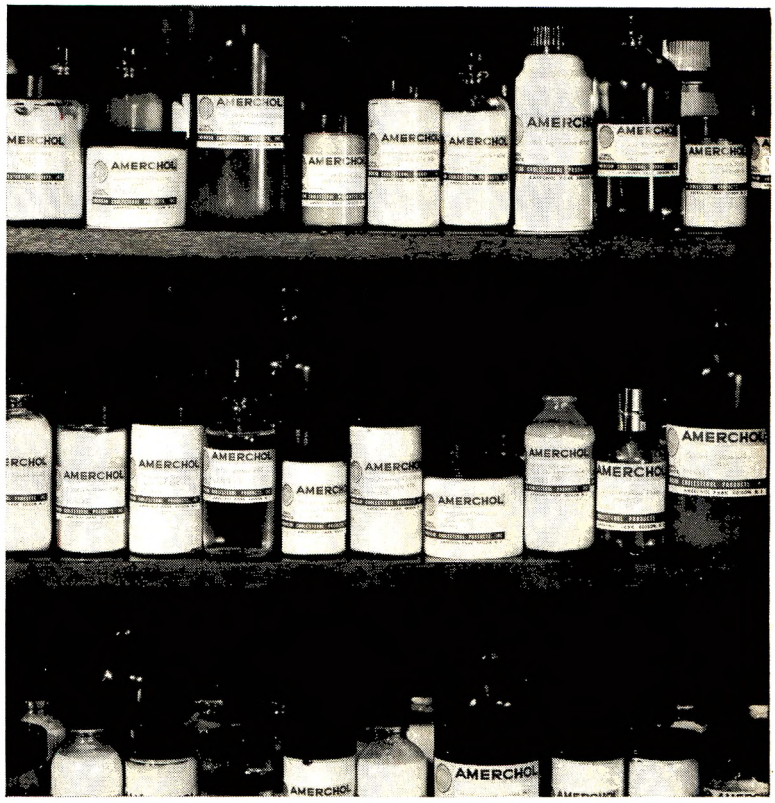

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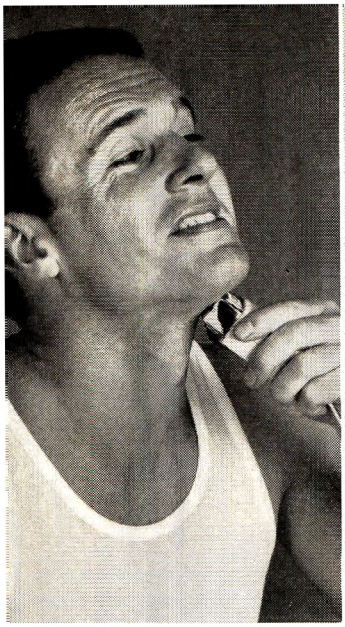

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May 8, 1963

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DURING THE annual meeting, Mr. Lester Conrad, President of the Society of Cosmetic Chemists, presented the Special Award for 1962 to Dr. Jerome Gross for *achievement in basic studies of the structure, function, reactivity and genesis of collagen.*

This Award is made possible through the continued interest and support of the following manufacturers, suppliers, testing laboratories and other companies in a joint effort to promote and encourage basic research in cosmetic science:

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JEROME GROSS, M.D.

A Eulogy by THOMAS B. FITZPATRICK, M.D.*

DR. JEROME GROSS might be said to have a one-track *scientific* mind. Only two of his fourscore publications have *not* been concerned with some aspect of the biology of connective tissue. He has adopted one of what I like to think are two types of approaches to scientific investigation: (1) to develop or become highly skilled in a technique and then use it to solve many and diverse problems; (2) another approach and the one that Dr. Gross has used is to concentrate on a subject and to apply all existing techniques, or develop new ones, but stubbornly to pursue the one subject. The electron microscopists are examples of the first type of approach, and Dr. Gross is a superb example of the second type. He has employed many and diverse techniques including electron microscopy, biochemical and physical chemistry and developmental biology to unravel the complexities of the biosynthesis of collagen.

Early in his career, Dr. Gross was fortunate to be guided by one of the pioneer molecular biologists, Professor Francis O. Schmitt of the Department of Biology, Massachusetts Institute of Technology. Together with Professor Schmitt, J. H. Highberger and others he carried out a comprehensive series of studies on the biophysical and biochemical properties of collagen. These investigators described the structure and composition of three forms of collagen and, after characterizing a kinetic unit designated "tropocollagen," subsequently defined the patterns of aggregation of tropocollagen in these three forms and the various factors which determine the interconvertibility of these forms. These studies are generally regarded as a significant contribution in the field of molecular biology.

His major objective has been to relate his research on the biosynthesis of collagen to growth, development, regeneration, aging, and to certain disease processes in man. Although Dr. Gross is a physician, he does not directly care for the sick; yet the results of his research may profoundly affect patient care. As a physician-scientist, he serves as a link between the patient and the molecule. As a scientist, he focuses on developing concepts of collagen biosynthesis and its control; as a physician he is polarized to the patient with disease because his laboratory is integrated in a large general hospital. He cannot forget the maimed or dying patients

* Harvard Medical School, Cambridge, Mass.

Mr. Lester Conrad (l.), President of the Society of Cosmetic Chemists, presents the Special Award for 1962 to Dr. Jerome Gross (r.).

with connective-tissue disease because they surround him. He would be the first to agree that disease exposes the secrets of the normal biology.

Charles Darwin in assessing his own success as a man of science attributed his achievements to "complex and diversified mental qualities and conditions." Among these he listed as the most important: "love of science—unbounded patience in long reflecting on any subject—industry in observing and collecting facts—and a fair share of invention as well as common-sense." These aptly describe Dr. Gross, and I congratulate your Society on giving him this Special Award. We are all proud of him at Harvard.

GUESSING IN BIOLOGY

Acceptance of the Special Award

By Jerome Gross, M.D.*

My sense of pleasure and of surprise were equally great on learning of this award you have given me. It is a very satisfying feeling to know that the work one is doing in a highly specialized and seemingly narrow area has evoked interest in totally unexpected quarters. I have also noted that a distinguished company of investigators has received this award, and I am honored to be listed among them. It is clear that the intellectual and scientific interests of your Society extend well beyond the confines of cosmetology.

When a man is given the privilege of speaking for fifteen minutes to an intelligent captive audience on a subject of his own choosing, the responsibility is considerable and the opportunity challenging. The easy way out is to discuss one's own work. Instead, I will take a risk and pose as a crystal ballgazer, focusing on a selected area.

The word is out that the near future will witness explosive advances in biology comparable with those in nuclear physics. This may well be true. The rapid advances in analytical techniques, both physical and chemical, which can be applied directly to biological systems have produced giant strides in our knowledge of the structure and function of the substances controlling heredity, in the detailed pathways of synthesis for both small and large biologically important molecules, and in our understanding of the structure and interactions between large molecules such as enzymes and tissue proteins, which are at the root of physiological function. Our new knowledge of the intimate structure of cells and tissues down to the molecular level is permitting us to make direct correlations between controlled test tube experiments and the related chemical reactions within the cells. The great advances in our knowledge of the chemistry of bacteria are providing considerable insight into the mechanisms which regulate synthesis and growth.

In my opinion, these advances are themselves the tools to be used in making possible the next biological giant step. My own crystal ball, along with that of others, projects an image of *developmental biology*, the field of study which examines the *changes* in structure and function

* Massachusetts General Hospital, Boston 14, Mass.

of an organism from its birth to its death. This field of study not only encompasses embryologic development but also senescence. I have a strong feeling that the processes which operate in aging may be more clearly manifest in early development but have been obscured by our highly prejudiced modes of thinking. If we can but understand how an organism changes its form and function with time we should learn more of the nature of congenital malformations, of the crippling deformities of chronic disease, the mechanism of healing and regeneration and perhaps the true nature of aging processes.

The vast descriptive knowledge accumulated during the past hundred years concerning the embryonic development of a variety of animals, plus the wealth of data obtained from more recent experimental embryology, provide the important biologic problems to be worked by the modern tools of molecular genetics, physical chemistry, metabolic chemistry, tissue fine structure analysis, and other rapidly advancing disciplines.

Among the many exciting embryological problems hanging like near ripe plums I would like to discuss three very briefly. It was observed more than forty years ago that if the several tissue layers of a variety of organs, such as epidermis and dermis of the skin, were cleanly separated and allowed to grow independently in tissue culture they underwent dedifferentiation to a rather nondescript appearing cell layer. However, if the two cell types were placed in contact with each other they would revert back to their original form and function, and the whole culture would then resemble the organization of the original complex organ. This was shown most dramatically in glandular tissue where the separated duct glands in culture grow out as a thin flat layer of cells. Upon adding back the connective tissue they immediately grow into a series of tubes and lobules nearly identical with the original glandular organ. It has been demonstrated by the interposition of a barrier such as a fine pored filter between the epithelial and connective tissue cells that some as yet unknown chemical substances pass from the connective tissue to the duct cells and induce them to differentiate. This type of experiment has been performed in innumerable ways. Whole young developing embryos have been completely taken apart, the cells dissociated from each other by chemical means to form a suspension and the scrambled cells pipetted into a culture medium. In the most incredible way these cells unscrambled themselves to reproduce a well-organized developing embryo. The experiment has been carried even further. The well-developed kidney of a hatched chick has been dissociated into suspensions of its individual cells and samples of these cell suspensions cultivated upon the membranes of an embryo chick. Within days these cells reassociated themselves into the highly specific organization recognizable as a chick kidney. The mechanism whereby this type of remarkable cell sorting and spontaneous reconstruc-

tion of an organ can occur remains shrouded in mystery at this time. However, on the molecular level we are learning rapidly the mechanism whereby populations of large molecules seek each other out in the test tube and under the influence of known physical chemical forces associate in the form of a fabric characteristic of the native tissue. The possible future implications of these experiments are clear and exciting. They should give us important insight into the forces and factors responsible for growth, form, specialized development, and the aberrations in the processes.

It has been well known for several hundred years that certain vertebrates can regenerate lost limbs. In 1768 the complete regeneration of the amputated limbs of the salamander was described in detail, and since that time libraries have been filled with published efforts to determine why the amphibian can regenerate a limb with a five-fingered hand composed of bones, joints, tendons, ligaments, muscles, nerve and skin, whereas mammals cannot. In the last few years there has been a new burst of activity in this field of study and new optimism with regard to the possibility of eventually learning how to regenerate functional structures in mammals.

A third area of considerable interest has to do with the manner in which an animal remodels his tissues during growth and development. It is clear that the structural changes in organs such as bone and skin during embryonic growth, maturation and senescence involve a continuous process of new synthesis of structural elements, their deposition in a highly organized fashion and their removal, all synchronized in time and space in such a way as to provide continuous changing shape without loss of function. In order to study this process most efficiently, one hunts up and down the animal kingdom for the best subject to use. Perhaps the most dramatic example of remodeling is to be found in the transformation of the lowly polywog into a frog under the influence of the thyroid gland. The bullfrog tadpole over a period of two years grows to an average length of six to eight inches, of which the long muscular tail accounts for two-thirds his length. During spontaneous metamorphosis induced by the outpouring of endogenous thyroid hormone, or by artificial induction through the addition of the hormone to the aquarium water, the entire tail may be resorbed within two weeks, the four legs will erupt almost overnight and grow at a fantastic rate, the gills will be completely resorbed and replaced by lungs, the mouth change in shape from a small round hole to a broad gaping slit and the eyes move from the sides to the top of the head. The entire coloration of the animal skin will change. During the time when the skin is being rapidly resorbed in the tail it is being thickened over the body with increased collagen formation in the dermis and the rapid growth of large mucus glands in the epidermis. Thus, skin in two different regions of the animal will behave entirely differently to the stimulus of a single hormone. We selected the metamorphosing frog tadpole

for study because it represents a highly exaggerated example of the same type of changes which take place during the embryonic growth and maturation processes in human beings. Here in the tadpole we can study the detailed chemical and morphologic processes under highly controlled experimental conditions. By restricting ourselves to one universally distributed tissue component, namely collagen, which is involved in all remodeling processes in higher animals, we hope to find those principles which are followed in the remodeling of all the other structural elements.

Once we understand the basic principles involved in any animal system and develop the necessary tools for studing these processes, we hope that we can in a much more effective and direct manner examine the analogous processes in the mammal.

We are painfully aware of the limitations of reason and may easily be led by nature down the well-known garden path. However, in any investigative work, it is well worth shooting for the stars with the hope that you also know how to keep at least a toenail on the ground.

Again, my many thanks to you for this handsome award.

NOTICE FROM THE EDITOR

To the Readers of THE JOURNAL OF THE SOCIETY OF COSMETIC CHEMISTS

In the past, THE JOURNAL OF THE SOCIETY OF COSMETIC CHEMISTS has been devoted primarily to the publication of original papers. The large amount of currently published scientific literature pertaining to cosmetic chemistry suggests that the JOURNAL might render a further service to its readers by including, from time to time, a review article. It is hoped that readers will find up-to-date review papers of value.

The goal of THE JOURNAL OF THE SOCIETY OF COSMETIC CHEMISTS is to be of service to all who practice the science of cosmetics. In order to fulfill this function, the JOURNAL will also publish "Preliminary Notes" from workers in the field to provide prompt publication of significant results. These Preliminary Notes can be followed later by a more complete publication or may be of such a nature that they require no follow-up. It is sincerely hoped that publication of short preliminary technical reports will be stimulating to the readers and will encourage members of the Society to make further contributions to the JOURNAL. Like all papers, Preliminary Notes must conform to the style requirements for publication in THE JOURNAL OF THE SOCIETY OF COSMETIC CHEMISTS (J. Soc. COSMETIC CHEMISTS **14,** 157–9 (1963)).

It will continue to be the primary purpose of the JOURNAL to publish original and complete papers contributed by members of the Society and other scientific workers. The Editor hopes that the JOURNAL will be strengthened as a forum for the dissemination of scientific work and will be used by cosmetic chemists for publication of their results.

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THE OSMOTIC BEHAVIOR OF HAIR DURING THE PERMANENT WAVING PROCESS AS EXPLAINED BY SWELLING MEASUREMENTS

By Albert Shansky, Ph.D.*

There are three types of forces which hold protein molecules in groups: (1) covalent cross links, (2) electrostatic salt bridges and (3) hydrogen bonds. These forces are largely responsible for the mechanical properties exhibited by protein fibers. The protein molecules of fibers such as hair or wool have their long dimension aligned with the axis of the fiber. The most important forces which hold these long molecules together in bundles are of the three types described above. The first of these is the covalent molecular cross link present in the cystine residues. The second is the salt bridge, which is the electrostatic attraction between oppositely charged side chain groups in adjoining molecules. Finally, there are hydrogen bonds between the N—H and C=O groups which are always present in protein fibers. These three types of lateral forces are important in determining the mechanical properties of fibers, and it is the purpose of this paper to report the effect of cold wave reagents on these three forces as characterized by the swelling and deswelling phenomenon of human hair fibers.

Cold wave lotions generally consist of approximately 8% ammonium thioglycolate solutions adjusted with ammonia to a pH of about 9.3. They have the capacity for breaking all three types of bonds.

The swelling of human hair is anisotropic; that is, the diameter changes are much larger than the length changes (1). The most direct method of determining dimensional changes is to observe them under a microscope. Other workers(2) have undertaken such measurements and have arrived at the conclusion that natural fibers are so irregular and nonuniform and the volume changes so small that even a large number of microscopic measurements will usually fail to yield quantitative data of good precision. Nevertheless, direct microscopic measurement has so much to recommend its use that it was felt the results obtained would be significant.

In general, microscopic swelling measurements were made on short lengths (2–3 cm.) of selected, nearly-round samples of human hair which had a dry diameter of 40–60 mμ. The samples were mounted in a small

* Rilling Dermetics Co., Bridgeport 7, Conn.

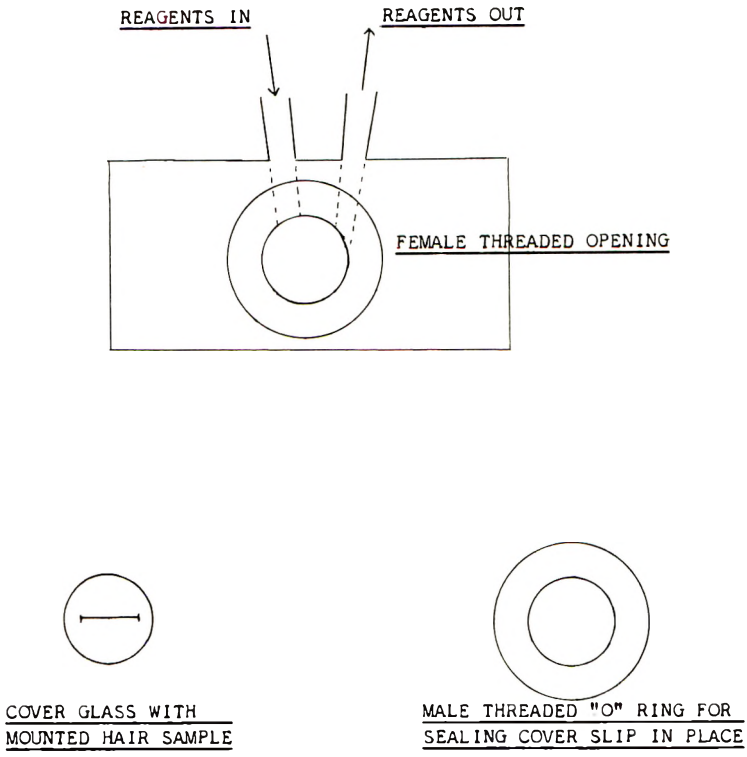

Figure 1.—Cell for making swelling measurements.

cell (Fig. 1) into which the passage of reagents could be controlled. All measurements were made with a filar micrometer eyepiece using a magnification of 260×. An average of 20 repetitive fiber measurements were used for each experiment.

In this study, the complete exposure of the hair fiber to the various steps of cold permanent waving was followed under a microscope, and the diameter changes which took place were observed. In the first experiment, a dry hair fiber was subjected to the usual permanent wave procedure within the cell as follows:

(1) wet with cold wave lotion for 3 minutes
(2) wash with deionized water for 1 minute
(3) neutralize with 1.5% H_2O_2 for 5 minutes

The cold wave lotion used had the following composition:

deionized water	66.8 gm.
ammonium thioglycolate 52%	11.3 gm.
ammonia 26–28%	3.0 gm.

This solution contains a concentration of 8.6% ammonium thioglycolate.

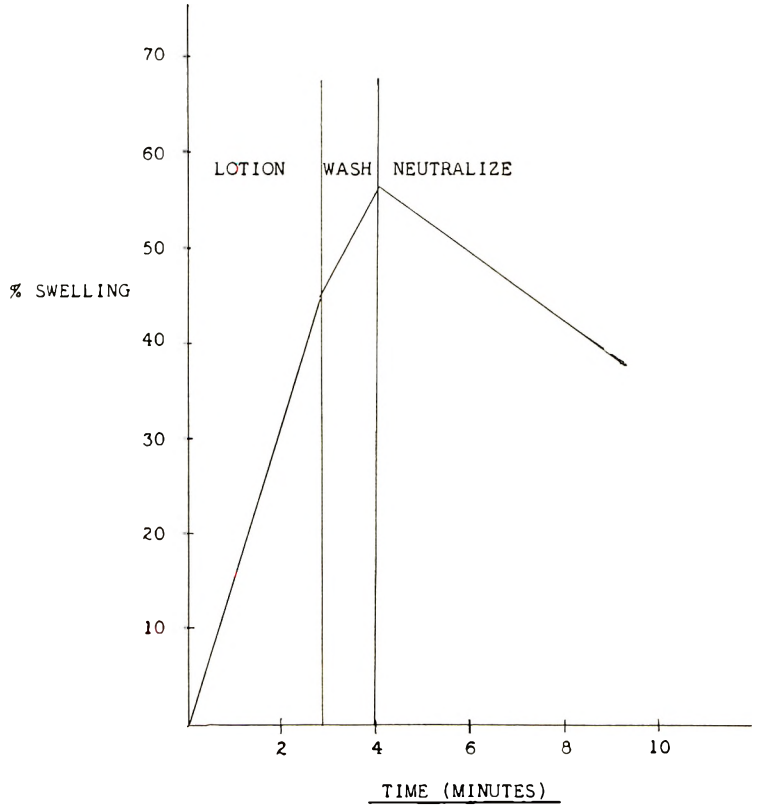

Figure 2.—Regular cold wave process.

In the graph (Fig. 2), it can be seen that in the first three minutes of exposure to the cold wave lotion there is a marked and sharp increase in fiber diameter. However, during the second step of rinsing and removal of the cold wave lotion, there is a further increase of diameter which is of paramount significance to this study. The third step of neutralizing reveals that a noticeable deswelling takes place. The following explanation is proposed:

It is almost axiomatic that in the first three minutes a rapid swelling occurs, due to the rupture of the three bond forces in the fibral structure. However, the additional swelling which takes place upon removal of the cold wave lotion can only be due to some external force influencing the physical state of the fiber, and it is believed that this further increase in swelling is due to osmotic pressure.

The cold wave lotion which is applied to the hair penetrates the fiber and initiates a swelling action by absorption (3). The environment surrounding the hair fiber consists of the ammonium salt of thioglycolic acid. After penetration into the hair shaft, the salt content is of equal

concentration on the outside of the hair as well as the inside. When the cold wave lotion is rinsed off the hair with water, there is an obvious decrease in salt concentration outside of the hair. However, the salt concentration remains comparatively higher on the inside of the hair. Theoretically, the hair, acting as a semi-permeable membrane, permits the natural travel of water from the outside of the hair (the less concentrated area) to the inside of the hair (the more concentrated area). In order to

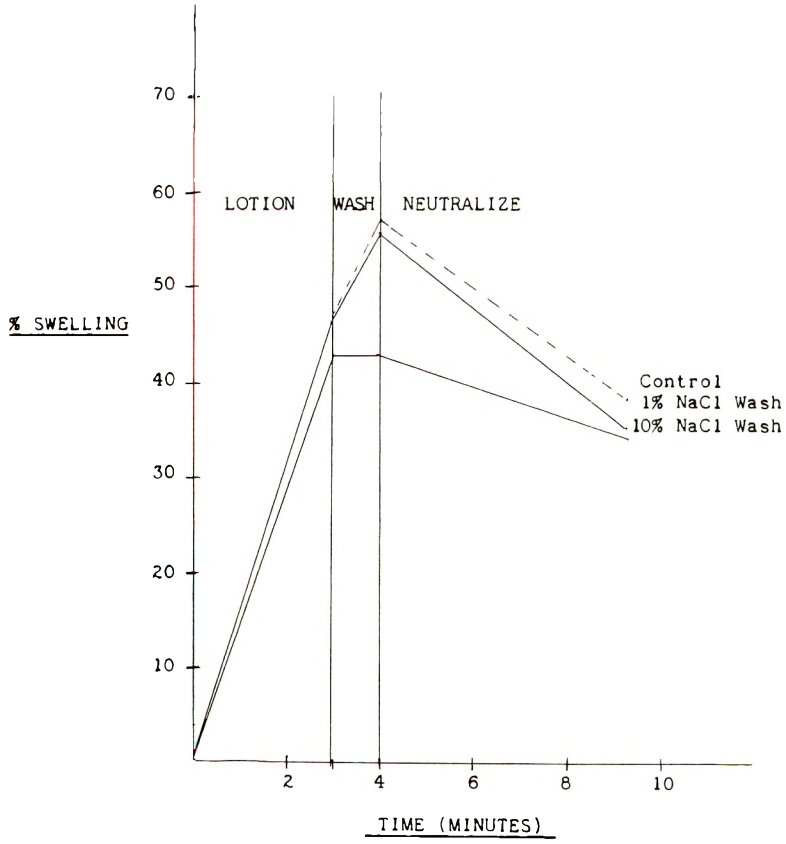

Figure 3.—Difference in swelling rates due to equalizing osmotic pressure during rinsing.

prove that this theoretical condition exists, an experiment was performed using various concentrations of salt solutions as the rinsing medium. The purpose in doing this was to see whether the osmosis of fluid into the fiber and subsequent swelling could be avoided.

In Fig. 3, it can be seen that the usual amount of swelling takes place within the first three minutes. At this moment, the cold wave lotion is rinsed from the hair for one more minute with deionized water. As can

be seen from the graph, this rinsing results in an additional swelling. Rinsing with a 1% NaCl solution showed no appreciable change from rinsing with water alone. Since the cold wave lotion used had a concentration of salt of 8.6%, a 10% NaCl solution was used to rinse the hair. This showed highly significant results. As can be seen (Fig. 3), there is complete flattening of the curve, showing no increase in swelling.

In all three cases, the hair was neutralized with a 1.5% hydrogen peroxide solution and, as can be seen, there is a significantly lower amount of energy

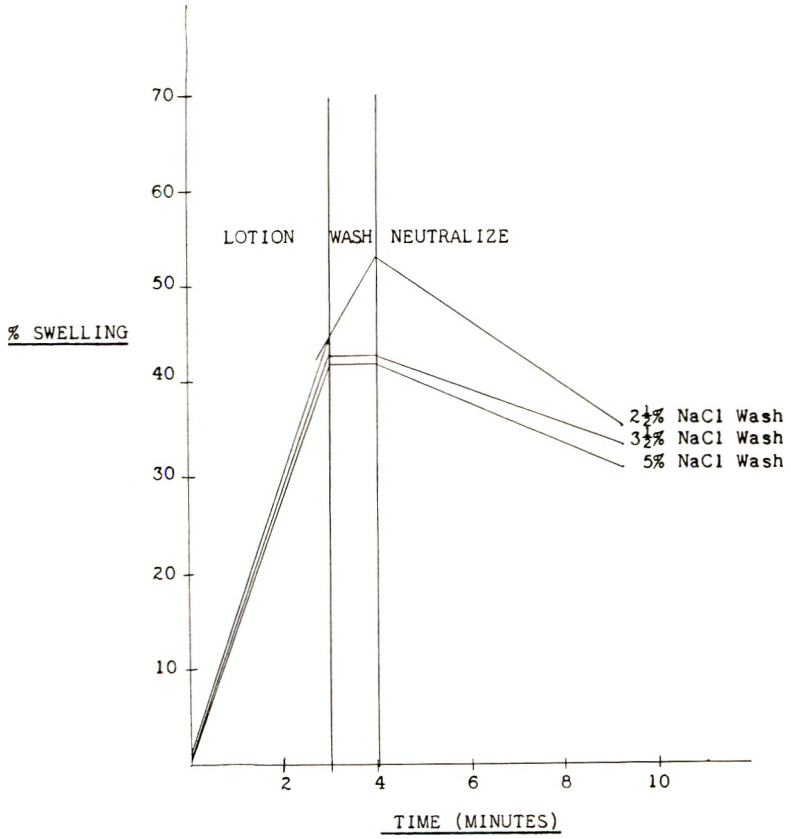

Figure 4.—Difference in swelling rates due to variation of salt concentration during rinsing.

required to deswell the hair with the neutralizer if the hair is first rinsed with the more highly concentrated sodium chloride solution. This is borne out by the differential in area beneath the curves between the four minute point and the nine minute point. Energy, in this case, refers to the capacity to do work even though the units of the area beneath the curve are not those of energy. Since energy is a product of the force and the distance through which the force moves, it can readily be seen that the

force is the osmotic pressure, and the distance through which the force moves is the diameter change. Therefore, the areas beneath the curves is an "index of energy," and significant data can be arrived at by this method if measurements of areas beneath the curves are made with a polar planimeter.

It was then decided that it would be useful to know that concentration of sodium chloride which could bring about no increase in swelling during the rinsing step. Or, to express it theoretically, what concentration of sodium chloride can equalize the osmotic pressure.

Using increments of about 1% NaCl concentration, it can be seen from Fig. 4 that $2^1/_2$% NaCl had no effect, whereas $3^1/_2$% NaCl had a significant effect and 5% NaCl had no greater effect. It can, therefore, be postulated from these results that a $3^1/_2$% NaCl solution in the surrounding medium (the rinse water) can equalize the osmotic pressure of an 8% ammonium thioglycolate solution on the inside of the hair. A quick calculation will reveal that a $3^1/_2$% solution of sodium chloride is 0.6 molar, while an 8.6% solution of ammonium thioglycolate is almost 0.8 molar. This disagreement is probably due to activity coefficients, temperature, and other undetermined factors.

It seems obvious from the foregoing that an interesting series of experiments could be devised to prove the postulated theories through osmotic pressure measurements. There is every reason to believe that such a study would contribute to an explanation of swelling behavior if the converse be true. The type of osmometer which could be used successfully in such work has been devised by Fuoss and Mead (4). The general procedures for measuring osmotic pressure have been described in the literature, by Flory (5) and by Wagner (6).

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COSMETICS VERSUS TOPICAL THERAPEUTIC AGENTS

BY IRVIN H. BLANK, PH.D. *

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ABSTRACT

There is a similarity in the composition of some types of cosmetics and topical therapeutic agents. Although the purposes for which comparable groups of products are used may not always be the same, their mechanism of action and their efficacy are frequently similar. The close relationship between some classes of cosmetics and topical therapeutic agents is discussed.

No longer is there a sharp dividing line between the interests of cosmetic chemists and dermatologists; both groups are working to devise ways of improving the condition and function of skin, hair and nails. The area of common interest is steadily expanding, but the objectives of these two groups are not identical. The dermatologist's primary interest is alleviation of existing or threatening pathology of immediate or potential severity, while the cosmetic chemist's primary interest is protection, improvement and minor alteration of relatively normal tissues.

In recent years, cosmetic chemists have done more than design preparations which counteract the symptoms of simple dryness and cover blemishes in the skin; they have also begun to add biologically active substances to their preparations and have thus made them somewhat analogous to certain pharmaceutical products. Consequently, it has become important to consider how certain types of cosmetic and pharmaceutical products resemble and differ from one another. No attempt will be made here to analyze specific products. The following categories of products will be discussed with emphasis upon their mechanisms of action: emollients, keratolytic agents, cleansers, antimicrobial preparations, antiseborrheic agents, antiperspirants and sun screens.

* Research Laboratories, Dept. Dermatology, Harvard Medical School, at the Mass. General Hospital, Boston 14, Mass.

1. Emollients

Emollients are used to counteract symptoms of dryness: (*a*) roughness of the cutaneous surface, and (*b*) decreased flexibility of the stratum corneum. They surely constitute one of the largest categories of cosmetic agents and include cold creams, lubricating creams, vanishing creams, bath oils and hand and body lotions. Dermatologists use similar preparations but usually refer to them all as emollients or protective agents and avoid the subgrouping found among cosmetics.

Although emollients may occasionally consist of a single oily substance, such as petrolatum, they are now usually composed of oil, water and an emulsifying agent. Bath oils, as marketed, seldom contain water; more frequently they contain a natural oil which has been chemically altered or mixed with an emulsifying agent, with the result that when used by the consumer they readily form an oil-in-water emulsion when added to water.

That water is a much better plasticizer of cornified epithelium than any oil is now well known and generally accepted (1). It is not necessary to review the background of this observation, but mention should be made of several misunderstandings which have arisen since this concept was introduced.

First, one should not conclude that the emollient action of an emulsion is necessarily better than that of an anhydrous oil simply because the emulsion contains water which might hydrate the stratum corneum. When an oil-in-water or a water-in-oil emulsion is spread on the skin, the small amount of water present can make only a minor contribution to the total prolonged emollient effect of the emulsion, because it soon evaporates. Water, alone, almost immediately relieves a sensation of dryness, but this relief is short-lived if the water is allowed to evaporate. When an occlusive film of anhydrous oil is placed on the cutaneous surface, the stratum corneum becomes hydrated by water which diffuses outward from the underlying tissues. Theoretically at least, an anhydrous oil might serve as a better emollient than an emulsion because the directly applied oil might be more occlusive than the oily film deposited from the emulsion and thus keep the stratum corneum hydrated for a longer time.

Second, retention of water by the stratum corneum is not the only mechanism by which an oily film exerts its emollient action. The oil is a "lubricant" and makes a rough cutaneous surface feel smooth.

Third, the naturally occurring film of oil on the cutaneous surface (sebum) is poorly occlusive and probably does not play a major role in retention of water by the stratum corneum. When there is a deficiency of sebum on the skin, either for natural reasons or because of removal by detergents or organic solvents, one might expect the skin to be rough and therefore it would seem dry because of this roughness and not because of any decrease in the flexibility of the stratum corneum.

Fourth, although *thick* stratum corneum, like that on the palms and soles, is relatively inflexible when dehydrated, *thin* stratum corneum may be relatively flexible even when its water content is low.

Fifth, the concentration of water is probably not uniform throughout the stratum corneum. In an environment of low relative humidity, water continuously diffuses from the moist layers of the epidermis through the relatively dry stratum corneum into the atmosphere. It has been shown that the lipid film on the surface of the stratum corneum is not the rate-limiting barrier to the diffusing water. Either the entire stratum corneum serves as a relatively homogeneous barrier or the more compact layer at the base of the stratum corneum serves as the rate-limiting barrier. In either case the outward movement of water can occur only when the water content of the inner layers is greater than the water content of the outer layers. The exact water content of the different layers of the stratum corneum under various environmental conditions has not been determined.

Sixth, while too little is known about potential alteration of the water-holding capacity of the stratum corneum in diseased states, it is known that disease often alters the thickness and texture of the cutaneous surface. Actually, even the slight roughening of the surface in mild chapping may always follow subclinical inflammation and may not develop simply as the result of abnormal environmental conditions without pre-existing inflammation.

A type of emollient more commonly found among cosmetics than among therapeutic agents is an aqueous solution or suspension of a strongly hygroscopic agent such as glycerin or sorbitol. It is not entirely clear just how such hygroscopic substances exert their emollient action. If anhydrous glycerin is put on the skin, it will at first withdraw water from the stratum corneum and thus temporarily make the skin more "dry." The water requirements of an applied hygroscopic agent can, however, be supplied from the environment as well as from the skin so that at equilibrium the requirements of both the stratum corneum and the hygroscopic material are satisfied (2). At any given humidity, the total amount of water retained equals the sum of the amount held by the stratum corneum and the amount held at that relative humidity by the hygroscopic material (3).

Bath oils may be of two varieties: those which are immiscible with water and form a layer on its surface and those which can be emulsified in water. When either type is used in the bath, it is likely that some oil will be deposited on the skin from the bath water (4). Although it is evident that a film so deposited acts as a lubricant, it is not yet known whether such a film is sufficiently occlusive to favor retention of water by the stratum corneum.

Evidence is still inadequate to show that lanolin or any purified fraction

of lanolin aids retention of water by the stratum corneum more effectively than do other oily materials.

2. Keratolytic Agents

Salicylic acid is the keratolytic agent most commonly used in products for topical therapy. This substance does not actually *dissolve* keratinized tissue as its name might imply; even 50% salicylic acid in an anhydrous vehicle has no observable keratolytic effect on a piece of dry callus. When salicylic acid ointments or plasters are applied to the surface of the skin, they cause retention of increased amounts of water in the stratum corneum because they are occlusive and because the low pH of the acid favors water retention (5). After this occurs, the softened cornified tissue can be easily removed by mechanical means. The keratin molecules probably undergo little chemical change during this process.

For cosmetic purposes, keratolytic agents are used to soften hair so that it can be removed (depilatories) or reshaped (waving preparations). To accomplish this, more potent keratolytic agents, which attack the keratin molecule itself, are needed; it is obvious that salicylic acid cannot do this. Formerly, inorganic sulfides at high alkalinity were employed for this, but alkaline thioglycolates have come into use since it was learned that these compounds soften hair. Thioglycolates attack the disulfide group of cystine (6); subsequent oxidation "neutralizes" the action of the thioglycolates. After neutralization, the hair becomes relatively normal again if the action of thioglycolate has not gone too far. Thus, it is seen that the action of the keratolytic agents present in cosmetic preparations used on hair differs appreciably from that of the keratolytic agents present in preparations used for topical therapy of the skin.

3 Cleansers

The dermatologist usually recommends relatively simple cleansing procedures. During the acute phase of a dermatitis, he may recommend that cleansing procedures be reduced to a minimum and that wet compresses be used. At the present time, there is a divergence of opinion among dermatologists as to whether soap does or does not aggravate a pre-existing dermatitis. Suskind (7) and Stoughton *et al.* (8) have presented evidence to indicate that patients with mild dermatitis can cleanse their skin with soap and water without causing further irritation. If a nonsoap cleanser is desired, nonalkaline synthetic detergents are available. Currently, however, the alkalinity of a soap is not thought necessarily to be injurious. An aqueous solution of sodium laurate is less irritating to the skin at pH 9.5 than at pH 7.5 (9).

Cleansing techniques which do not involve the direct application of water or water and detergent are not infrequently recommended by both

dermatologists and cosmetic manufacturers. Mineral oil or some other oily anhydrous material is occasionally used for cleansing diseased skin. Cleansing creams and baby oils are among the agents advocated for normal skin by cosmetic manufacturers and sometimes by dermatologists. Most cleansing creams contain small amounts of water, but many baby oils are anhydrous; both are recommended for use without additional water, on the assumption that water and a mild cleanser might be injurious to the skin of the infant or the face of the adult. It is likely, however, that the judicious use of water and a cleanser does not injure normal skin or some abnormal skins and that, in fact, this more efficient type of cleansing may be beneficial if not repeated too frequently (10).

Currently, most shampoos are formulated from synthetic, anionic surface active agents. These substances are excellent cleansing agents in both hard and soft water; indeed, they often clean so well as to make the hair temporarily "unmanageable" after a shampoo, so far as grooming is concerned. Such removal of sebum probably does not damage the skin of the scalp, but it may loosen flakes of the stratum corneum and thus make "dandruff" more apparent.

4. Antimicrobial Preparations

Antimicrobial substances are used topically by the physician for both prophylactic (surgical scrub, preparation of the surgical field) and therapeutic purposes. They are incorporated in cosmetics as deodorants and as a means of combating the microörganisms thought to be involved in seborrheic conditions.

Antimicrobial agents may be either bactericidal or bacteriostatic in their action. The bactericides kill viable organisms rapidly and directly; the bacteriostats prevent their multiplication without killing them. Since the life span of a single, nonsporulating microörganism is short, a population of these organisms will eventually be destroyed by any substance which prevents their multiplication.

At the present time, alcohols and antibiotics are the bactericidal agents most commonly used in both cosmetic and pharmaceutical preparations. Alcohol has a wider spectrum of activity than do the antibiotics (11). Hexachlorophene is probably the most commonly used bacteriostatic agent.

Antibiotics are incorporated into both ointments and lotions, bacteriostatic agents into ointments, lotions and cleansing preparations. Substances like hexachlorophene are effective when incorporated in cleansers because they are substantive to the skin (12) and are deposited on the skin in small amounts during the cleansing process.

For prophylactic use, surgeons and dermatologists have found that topical antimicrobial agents are quite satisfactory; for the treatment of cutaneous disorders known to be of microbial origin, on the other hand,

these agents are less satisfactory. There is an increasing tendency to use systemic rather than topical therapy for these disorders.

The exact pathogenesis of neither mild seborrhea (dandruff) nor mild acne is yet known, and it remains to be shown whether bacteria play an important role in the pathogenesis of these disorders. Control of bacteria by topical antimicrobial agents may therefore not affect the course of these diseases.

There can no longer be much doubt that the control of bacterial multiplication on the cutaneous surface will diminish and alter body odor. The use of antimicrobial agents in deodorants is therefore well justified.

5. Antiseborrheic Agents

The two so-called seborrheic disorders for which cosmetics are marketed are dandruff and acne. To counteract dandruff, antiseborrheic agents are incorporated into both hair lotions and shampoos. Various lotions and ointments are available for the treatment of "adolescent pimples" (mild acne).

Since neither the specific etiology nor the pathogenesis of dandruff and acne is known, one can hardly speculate about how antiseborrheic agents act upon these conditions. Sulfur is commonly used as an antiseborrheic agent. Selenium sulfide, zinc pyridine thione and other agents have been added to shampoos in recent years and recommended for the control of seborrhea of the scalp. The specific mechanism of action of these agents is controversial, and there is a dearth of good clinical data to prove that all of them control seborrhea or "cure" dandruff or acne.

6. Antiperspirants

Antiperspirants, such as aluminum salts, are used for the most part to control the delivery of sweat to the cutaneous surface of the axilla. Differences of opinion currently exist as to whether or not topically applied antiperspirants do effectively reduce sweating. It is difficult to obtain reproducible data on the delivery of sweat. If antiperspirants are effective, the duration of their effectiveness after application may depend on environmental conditions, psychic stress, number of previous applications, etc. Since most of the sweat in the axilla is produced by the eccrine glands, an effective antiperspirant might be expected to reduce the activity of these glands. Just how this can be accomplished by a topically applied substance is not clear.

The physician is not infrequently asked to help control hyperhidrosis of the palms and soles. The antiperspirants used in cosmetics are rarely, if ever, effective for this purpose. Solutions of formaldehyde may be helpful (13), although irritation may follow their use. The mechanism of action of formaldehyde is not known.

7. Sun Screens

The agents currently used as sun screens in cosmetics and pharmaceutical preparations are similar. They include the esters of *p*-aminobenzoic, anthranilic, salicylic and cinnamic acids which absorb ultraviolet radiation, primarily of wavelengths between 290 and 320 mμ. Recently, the benzophenones (14), which absorb the longer wavelengths, and the acrylonitriles (15) have been recommended for use in pharmaceutical preparations.

For cosmetic purposes, it might seem ideal to have a sun screen which would completely prevent sunburn and permit tanning which persists. There is doubt, however, whether such tanning can take place without at least some degree of previous burning. This type of tanning is dependent upon the formation of new melanin which in turn probably occurs only after cells have been injured in some way. Mild erythema (sunburn) may therefore be a prerequisite to a persistant tan.

More recent work (16) has shown that the spectral range which can cause the formation of new melanin extends considerably beyond 320 mμ, possibly to 650 mμ. Even at these longer wavelengths, erythema often precedes the formation of new melanin in Caucasians, but at times pigmentation appears to develop without clinical evidence of erythema.

Photosensitivity and phototoxic reactions may follow exposure to the longer ultraviolet wavelengths (greater than 320 mμ) and visible light. Since most of the sun screens used in cosmetics effectively absorb only radiation up to 320 mμ, they are not satisfactory for use by a patient who has a photosensitivity.

Summary and Conclusions

There is an ever increasing similarity between the agents used in some cosmetics and some topical therapeutic preparations. Although the intended function of many cosmetics is the maintenance and/or improvement of the characteristics of relatively normal skin, while the intended function of topical therapeutic agents is usually the "cure" of abnormal skin, the general composition and mechanism of action of several categories of products overlap.

Emollients are common to both cosmetics and therapeutic preparations. Their mechanism of action has received considerable attention in recent years and is now fairly well understood. Some misunderstandings which have arisen have been reviewed.

For cosmetic purposes, keratolytic agents are often used to soften hair; the topical therapeutic agents of the dermatologists, on the other hand, are used to soften keratinized epithelium. Their compositions necessarily vary, as do their mechanisms of action.

Although cosmetic cleansers are often similar to the cleansers recommended by dermatologists, both dermatologists and cosmetic chemists at

times suggest the use of "nonsoap" cleansers, some to be used with water and some without. The judicious use of soap and water for personal hygiene is seldom harmful to normal or to many abnormal skins.

Topical antimicrobial agents effectively reduce the bacterial population of normal skin. For this, they are successfully used prophylactically by surgeons and dermatologists. Cosmetic manufacturers recommend them for control of body odor. Some dermatologists feel that known infections of the skin should be treated systemically rather than by topical antimicrobial agents.

There is as yet inadequate evidence to prove that microörganisms are important etiologic agents for cutaneous disturbances in the seborrheic areas of the skin (acne and dandruff). Some antiseborrheic agents may have antimicrobial properties, but it is not yet established that their mechanisms of action are dependent upon these properties. The exact mechanism of action of such agents as sulfur, selenium sulfide and zinc pyridine thione is not known.

If aluminum salts successfully reduce the amount of sweat delivered to the cutaneous surface, the mechanism whereby they do this is not clearly understood. The dermatologist finds it difficult to control excessive sweating of the palms and soles by any topical therapeutic agents.

For a very few people who have specific photosensitivities, it is important to protect the skin against a wide spectrum of the sun's radiant energy. This can be accomplished with partial success by some sun screens. The objective of the cosmetic sun screen is to protect the skin against too much exposure to the erythema-producing spectrum and permit the pigment-producing spectrum to reach the skin. This may be possible with the careful choice of the sun screening chemical and with avoidance of excessive exposure.

It is thus apparent that there is sufficient overlapping of the interests of cosmetic chemists and dermatologists to render cooperative effort profitable to both groups.

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CORRECTION

In Volume XIV, No. 6, the heading for the formula on page 267 should read ROSENOXIDES, not LEAF ALCOHOL; the heading for the formula on page 268 should read LEAF ALCOHOL Hex-3-en-1-ol.

NEW ASPECTS OF THE EFFECTS OF GELATIN ON FINGERNAILS

by Joseph B. Michaelson, Ph.D.
and David J. Huntsman, B.S.*

Abstract

Investigations made on the effects of orally administered gelatin reveal that gelatin increases significantly the hardness of fingernails and apparently improves nail defects in normal subjects.

The use of the technique of measuring the hardness of fingernails as a tool for evaluating the effects of gelatin (or other substances) is described.

The data is discussed in terms of a "specific" action of gelatin on fingernails possibly occurring through the metabolism of amino acids inherent in gelatin or the specific dynamic action of gelatin.

Introduction

In recent years many attempts have been made to determine the effects of gelatin on the condition and structure of fingernails. Tyson (1) reported in 1950 that oral ingestion of 7.0 g. of gelatin per day for three months returned fragile fingernails to practically normal appearance and texture. McGavack (2) obtained a similar finding in three to twelve weeks when gelatin was administered orally at a dosage of 7.5 g. per day. Rosenberg, *et al.* (3) observed improvement in 43 of 50 subjects with brittle nails after three months of ingestion of 7.0 g. of gelatin per day. In earlier studies Rosenberg and Oster (4) noted improvement after three months in 26 of 36 subjects receiving 7.0 g. of gelatin per day. Schwimmer and Mulinos (5), using a dosage of 7.5 g. of gelatin per day, found improvement in 14 of 17 subjects after three months. Derzavis and Mulinos (6), in a series of experiments, evaluated the improvement of fingernails during oral administration of gelatin at different dosages. These investigators used a dose of 1.8 g. per day in one set of experiments and 7.0 g. per day in another. They reported a $2^1/_2$ times improvement in the nails of the test subjects at the lower dosage of gelatin compared to the placebo subjects and 5 times improvement in subjects receiving 7.0 g. of gelatin daily.

In all of these investigations no attempts have been made to determine the minimum gelatin requirements necessary to evoke a response measured

* Applied Biological Sciences Laboratories, Inc., Glendale 1, Calif.

in the form of an improvement in nails or the minimum time required to obtain an improvement. Moreover, no adequate methods have been developed with which to measure the responses of the fingernail to orally administered gelatin. Observations to date for the most part have been based on either the visual observations of the investigator in terms of nail improvements or the result of conclusions drawn through interrogation of the test subjects.

In view of these facts we became interested in the possibility of correlations which might exist between physical testing procedures and the visual observations noted by many investigators. On a preliminary basis we undertook a study relating hardness of fingernails to intake of gelatin and visually observed changes in the condition of fingernails. This paper presents the methods and results of this investigation in these and related terms.

Method

For this study we selected 15 adults—8 males and 7 females—varying in age from eighteen to fifty years. All test subjects used in these studies were chosen according to the criteria of good physical health, willingness to cooperate, interest, etc.

The subjects selected had an array of nail defects including chipping, peeling, lamination and breaking, but care was taken not to choose subjects with obvious nutritional, endocrinal or fungal disturbances.

No attempt was made to differentiate the subjects as to age, occupation, dietary requirements, etc. It was our intent to conduct this investigation utilizing healthy adults in order to evaluate the intake of gelatin in normal individuals under ordinary circumstances rather than as a therapeutic agent or adjunct. In our opinion randomization of the type specified in our selection of individuals reduced variables which would be manifest in pathogenic conditions and allowed for an investigation utilizing a "cross section" type of approach under everyday conditions. The volunteer test subjects were instructed not to change or modify any of their habits or daily routines during the course of this study, and the use of such things as detergents, soaps, nail polishes, etc. was not prohibited.

After the test subjects were selected they were divided into two groups. Group A consisted of 2 males and 5 females; Group B was comprised of 6 males and 2 females. Group A received gelatin in capsule form and Group B, lactose placebos. Each group was instructed to ingest one capsule (0.67 g.) three times a day. This regimen was followed for a period of five months. The five-month time period for this study was selected because it has been reported that definitive effects of oral ingestion of gelatin could be shown in eight to sixteen weeks (3, 4 and 5).

Just prior to the start of these studies the nails of each subject were

examined, and the type of nail defects observed were recorded. Following this examination samplings of three nails from each individual used in this investigation were taken and subjected to tests to determine the relative degree of hardness of each nail sample. The nail samples were collected on a random basis. In subsequent samplings the same nails were used as for the initial sampling. At intervals of one, two and five months following the start of this investigation—ingestion of supplemental gelatin or placebos —the nails of all subjects were examined and sampled for hardness testing, the same nails being sampled at each time interval as initially. In addition, at the end of five months following initiation of the study all subjects were surveyed with respect to improvements in the condition of their nails which they observed. The data so obtained was later correlated with the observed changes noted by the investigator.

Hardness testing was conducted with the use of a Kentron Micro-Hardness Tester ®* which employs the principle of indentation of a test substance under a fixed weight. The Kentron Micro-Hardness Tester consists of a ridged beam mounted on flexure plates allowing normal rotational movement about only one axis. To the beam is attached an indenter and a test load. The indenter is held in an elevated position by raising the beam with a system of levers held in place by a latch. The indenter is allowed to descend at a selected constant rate of speed by releasing the operating lever. The speed of descent is controlled by a variable speed oil dash pot to which the beam is linked. The indenter will descend until it meets the surface of the specimen and completes the indentation. The indentation is measured with the aid of a standard metallurgical microscope provided with the hardness tester. The microscope is equipped with a filar micrometer eyepiece and the length of the indentation is measured in filar units. Filar units are converted into microns for subsequent calculations of the hardness number or value desired. (1 Filar Unit = 0.1 Microns)

The indenter used in our research was the Knoop Diamond Indenter, which is cut in the shape of a diamond-based pyramid giving a diamond-shaped impression, in which the long diagonal is nearly seven times the length of the short diagonal. The included longitudinal angle, measured from edge to edge, is 172° 30′, and the transverse angle is 130° 00′. Because of the difference in the lengths of the two diagonals, almost all of the elastic recovery of the indentation made with the Knoop Indenter takes place in the transverse direction. Hence, the measurement of the long diagonal together with the computed indenter constant gives a very close approximation of the unrecovered projected area of the indentation in square millimeters. The relationship between the applied load in kilograms and the approximate unrecovered projected area in square milli-

* The Torsion Balance Co., Clifton, N. J.

meters is called the Knoop Hardness Number for the specimen for that applied load.

The Knoop Hardness Number is expressed by the formula

$$KN = \frac{L}{(Ap)} - \frac{L}{(l^2)(Cp)}$$

where

KN = Knoop Hardness Number
L = Load in kilograms applied to the indenter
Ap = Unrecovered projected area in square millimeters
l = Measured length of the long diagonal of the indentation in millimeters
Cp = Constant relating "l" to the unrecovered projected area of the indentation. For an indenter with a longitudinal angle of 172° 30′ and a transverse angle of 130° 00′, $Cp = 7.028 \times 10^{-2}$

Moreover, since the impressions which result from the use of the Knoop Indenter are rhomboidal with the long axis approximately 30 times the depth of impression measurable, indentations can be made on extremely thin sections of specimen. This fact, considered with the observation that round or square indentations cause extreme fracturing on brittle substances, predicated our choice and use of the Knoop Indenter. (A complete description of the Knoop Indenter may be obtained from the Department of Commerce, National Bureau of Standards, Washington, D. C.)

Test loads to be used are determined by trial on the materials being tested so that the length of the indentation falls within an accurately reproducible range. In our experiments loads used were in the range of 4.1 to 7.1 kg.

The total time allowed for the descent of the Knoop Indenter used in our studies (rate of speed) was fixed at 20 seconds. This rate of speed of descent of the indenter was determined by trial of different speeds under selected weight loads until the reduction of the rate no longer affected the average length of the indentations or until the length of the indentation was constant. This method of load application eliminated error due to impact.

Prior to the actual process of indenting the specimen, the nail samples were lightly polished with 3/0 sandpaper. This procedure was employed since the amount of surface preparation necessary to make a microhardness test will vary with the indenter and test load to be used and the hardness of the material to be tested. The amount of polish required was determined by the ability to define the tips of the indentation and to develop the characteristic rhomboidal shape of the indentation.

Thickness of the nail samples was eliminated as a variable in our work because with the indenter and the weight loads used, no fracturing of the test nail specimens or depressions exceeding the thickness of the nail samples occurred. Fracturing of the specimen or the formation of indentations deeper than the thickness of the sample are factors directly related to

thickness and can be avoided only by selection of the correct speed-weight-depth relationship.

In our work the test nails, varying in length from 2—4 mm., were fastened to a steel block with cellophane tape with the long diagonal of the concave surface of the nail parallel to the axis of the indenter used to minimize error due to curvature.

Three Knoop hardness determinations were made on each nail sample, and the average of the three determinations was recorded. The degree of hardness of the initial samples (Knoop Hardness Number) was recorded as the base line value, and all subsequent values obtained were compared on a relative basis to the initial values. An increase or gain in hardness relative to the initial readings was recorded as a positive (+) change and a decrease as negative (−). No change was recorded as zero (−0−) change.

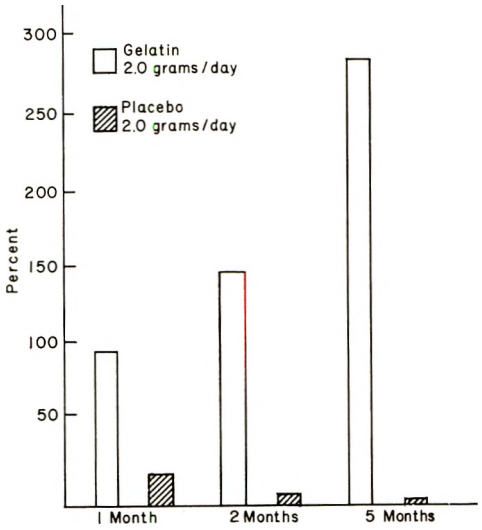

Figure 1.—Average degree of hardness gain.

The per cent change in hardness for each nail sample was calculated at each time interval specified. All data obtained were subjected to statistical evaluation using the chi-square method (7). In all instances the data were computed using a probability factor of 0.01.

Results

The subjects in this investigation were studied through two seasonal periods. In the tabulation of the results, however, no particular variations due to seasonal effects were observed. The data obtained in these studies are given in Tables I and II. Tables III and IV and Fig. 1 set forth the results of the analyses of the data.

TABLE I—AVERAGE CHANGES IN HARDNESS—GELATIN REGIMEN

Subject	Weight Load in Grams	Nail Sample*	Knoop Hardness Numbers Initial	1 Month	2 Months	5 Months
B	4100	R-1	1,344	6,613	9,114	33,563
(Female)		R-3	7,708	7,708	6,613	12,046
		R-5	7,708	4,170	7,708	9,114
J		L-4	3,211	6,810	8,698	14,491
(Male)	7100	R-4	3,211	8,158	10,650	17,253
		R-5	1,752	5,781	6,810	4,310
K		L-3	6,099	12,617	9,273	8,158
(Female)	7100	L-5	5,781	11,452	14,491	8,158
		R-5	631	1,656	1,338	9,926
C	4100	L-5	11,452	5,355	5,732	6,613
(Female)		R-4	3,338	10,918	9,967	7,708
		R-5	5,773	40,340	48,216	6,613
I		L-4	7,668	8,158	14,491	28,925
(Female)	7100	L-5	6,810	3,495	8,158	15,783
		R-5	25,787	11,452	32,568	68,898
M		L-1	414	526	502	572
(Male)	7100	L-3	509	654	666	772
		R-1	3,946	6,099	8,158	9,926
N		R-3	3,088	3,946	7,668	5,214
(Female)	7100	R-4	1,485	2,037	2,971	3,779
		R-5	677	1,241	1,547	1,656

* L-1 = Left Thumb, L-2 = Left Index, L-3 = Left Middle, L-4 = Left Ring, L-5 = Left Little, R-1 = Right Thumb, R-2 = Right Index, R-3 = Right Middle, R-4 = Right Ring and R-5 = Right Little.

TABLE II—AVERAGE CHANGES IN HARDNESS—PLACEBO REGIMEN

Subject	Weight Load in Grams	Nail Sample*	Knoop Hardness Numbers Initial	1 Month	2 Months	5 Months
R	7100	L-4	4,310	8,698	6,810	7,668
(Male)		L-5	3,627	6,810	6,099	4,310
		R-5	2,971	7,221	6,445	5,214
Q	7100	L-5	580	494	509	561
(Male)		R-3	580	631	580	526
		R-5	757	703	703	631
P	7100	L-5	2,037	1,805	1,704	1,525
(Male)		R-3	1,805	2,037	1,805	1,805
		R-5	1,805	1,446	1,610	2,320
O	7100	L-5	6,445	7,221	6,810	5,781
(Male)		R-3	4,210	5,214	4,120	3,495
		R-5	8,158	10,650	6,810	9,273
H	6100	L-5	1,464	1,464	1,384	1,750
(Male)		R-3	1,066	970	965	926
		R-5	926	1,017	1,058	778
E	4100	L-4	2,007	2,182	2,009	1,854
(Female)		L-5	2,092	2,379	2,279	2,092
		R-5	1,253	1,108	1,141	1,141
D	4100	L-4	1,254	1,254	1,176	1,176
(Female)		L-5	1,254	1,538	1,176	1,214
		R-5	1,254	1,254	1,214	1,254
L	7100	L-3	25,539	15,783	15,783	20,860
(Male)		L-5	3,088	3,341	3,088	3,475
		R-5	68,898	68,898	49,466	58,121

* L-1 = Left Thumb, L-2 = Left Index, L-3 = Left Middle, L-4 = Left Ring, L-5 = Left Little, R-1 = Right Thumb, R-2 = Right Index, R-3 = Right Middle, R-4 = Right Ring and R-5 = Right Little.

TABLE III—ANALYSIS OF THE EFFECT OF GELATIN ON FINGERNAILS

Subject	Nail Sample*	% Change in Hardness† 1 Month	2 Months	5 Months	Observed Improvement (5 Months)	Subject's Expression of Improvement (5 Months)
B	R-1	+392	+578	+2397	Absence of peeling	Increased resistance to splitting and peeling. Nails seem stronger
(Female)	R-3	−0−	−14	+56		
	R-5	−45	−0−	+18		
J	L-4	+112	+170	+351	Absence of chipping and breaking	Increased resistance to chipping and breaking. Nails seem stronger and more lustrous, grow faster
(Male)	R-4	+154	+231	+437		
	R-5	+229	+288	+163		
K	L-3	+106	+52	+33	Absence of peeling and chipping. Nails thicker	Increased resistance to chipping and peeling. Nails seem harder and grow faster
(Female)	L-5	+98	+150	+41		
	R-5	+162	+112	+1472		
C	L-5	−53	−49	−42	None	Increased resistance to chipping
(Female)	R-4	+227	+198	+130		
	R-5	+598	+735	+14		
I	L-4	+6	+88	+277	Reduction in splitting	Nails feel harder and show less splitting
(Female)	L-5	−48	+19	+131		
	R-5	−55	+26	+167		
M	L-1	+26	+21	+39	Reduction in chipping. Increased luster	Increased resistance to chipping; nails feel harder and grow faster
(Male)	L-3	+28	+30	+51		
	R-1	+54	+106	+151		
N	R-3	+27	+148	+68	Reduction in peeling	Increased resistance to peeling and breaking. Nails feel harder and grow faster
(Female)	R-4	+37	+100	+154		
	R-5	+83	+128	+144		

* L-1 = Left Thumb, L-2 = Left Index, L-3 = Left Middle, L-4 = Left Ring, L-5 = Left Little, R-1 = Right Thumb, R-2 = Right Index, R-3 = Right Middle, R-4 = Right Ring and R-5 = Right Little.

† (+) = Increase in Hardness, (−) = Decrease in Hardness, and (0) = No Change in Hardness.

In calculating the per cent change in hardness, expressed in Tables III and IV, all data were subjected to statistical evaluation using the chi-square method (7). A chi-square test is applicable whenever one or more differences are compared with expectation based upon a hypothesis. We started with the negative hypothesis that there would be no change in hardness between those nails subjected to placebos and those subjected to the gelatin. A significant value of chi-square denotes a sample so discrepant as to bring into doubt the hypothesis set up; any chi-square beyond 6.635 (a probability value of 0.01) is *large* and suggests rejection of the hypothesis. The larger the value of chi-square, the stronger the evidence against the hypothesis.

In the data in Tables III and IV, the per cent change was recorded when the chi-square value was 6.635 or greater, and therefore considered significant; the values were recorded as no change (0) when the chi-square value was less than 6.635.

Tables I and II present the changes in hardness, expressed as Knoop Hardness Numbers, for the nails of subjects on the gelatin regimen and the placebo regimen, respectively. Each value shown is the average of three measurements made on a single nail sample.

In Table III is recorded an analysis of the data obtained with subject individuals on the gelatin regimen. Examination of the data in Table I reveals several significant observations. First, in all of the test subjects there was a significant increase in the hardness of the fingernail during the course of the study. Moreover, as indicated in Table III this increase can be seen to occur in five of the seven test subjects within a period of one month following initiation of the gelatin regimen. At the end of two months all of the subjects showed a significant increase in the hardness of their fingernails. However, at the end of five months Subjects K and C showed a softening effect. When surveyed both subjects stated that during the fourth and fifth months of this study they were "continuing to take the capsules but not as often." Noteworthy, as indicated in Table III, is the variation in the per cent increase in hardness in the nail samples of any one test subject. This is particularly significant in the case of Subject B.

Also of importance is the relatively high degree of correlation of observed improvements in nail condition to the subject's expression of improvement.

Table IV presents the analyzed data obtained with test subjects receiving placebo capsules. Although an initial increase in the hardness of the

TABLE IV—ANALYSIS OF THE EFFECT OF PLACEBO CAPSULES ON FINGERNAILS

Subject	Nail Sample	% Change in Hardness† 1 Month	2 Months	5 Months	Observed Improvement (5 Months)	Subject's Expression of Improvement (5 Months)
R	L-4	+101	+58	+77		
(Male)	L-5	+87	+68	+18	None	No improvement
	R-5	+143	+117	+75		
Q	L-5	−0−	−12	−0−		
(Male)	R-3	−0−	−0−	−0−	None	No improvement
	R-4	−0−	−0−	−16		
P	L-5	−0−	−16	−25		
(Male)	R-3	+12	−0−	−0−	None	No improvement
	R-5	−19	−10	+28		
O	L-5	+12	+5	−10		
(Male)	R-3	+26	−0−	−15	None	Nails seem to grow faster
	R-5	+30	−16	−13		
H	L-5	−0−	−0−	+19		
(Male)	R-3	−9	−9	−13	None	Nails seemed smoother
	R-5	+9	+14	−16		
E	L-4	+8	−0−	−7		
(Female)	L-5	+13	+8	−0−	None	No improvement
	R-5	−11	−8	−8		
D	L-4	−0−	−0−	−0−		
(Female)	L-5	+22	−0−	−0−	None	No improvement
	R-5	−0−	−0−	−0−		
L	L-3	−38	−38	−18		
(Male)	L-5	+8	−0−	+12	None	No improvement
	R-5	−0−	−28	−15		

* L-1 = Left Thumb, L-2 = Left Index, L-3 = Left Middle, L-4 = Left Ring, L-5 = Left Little, R-1 = Right Thumb, R-2 = Right Index, R-3 = Right Middle, R-4 = Right Ring and R-5 = Right Little.

† (+) = Increase in Hardness, (−) = Decrease in Hardness, (O) = No change in Hardness.

fingernails of these subjects was found, it can be noted that the nails of individuals receiving placebos showed a general tendency to soften as the experiment proceeded. Individual variation in the hardening or softening of the nails of any one subject can also be observed from this data. The striking increase of hardness in the nails of Subject R cannot be fully explained within the scope of the present study. However, it is important to note that at the end of five months the nails of Subject R were softer than at the start of this study. Furthermore, no significant visual improvements in the nails of subjects on placebos were found in contrast to the data obtained with subjects ingesting gelatin.

In Fig. 1 data relative to the average degree of hardness gained for each group of subjects are expressed as per cent gain in hardness. This data shows an average gain in hardness of 102% as early as one month following ingestion of 2.0 g. of gelatin per day. With continued ingestion of gelatin the nails of test subjects showed a continued increase in hardness. From Fig. 1 it can be seen that the nails of subjects receiving placebos showed a slight increase in hardness at the end of the first month. However, at the end of two and five months the nails of these subjects showed a decrease in hardness relative to that observed at the end of the first month.

Discussion

Investigators in the past concerned with studies on the effect of gelatin on fingernails have been handicapped by lack of effective methods and techniques with which to make measurements of changes occurring in the nails of test subjects. As a result the beneficial effects of gelatin taken daily have not been observed or explained adequately. The present study suggests that the testing of nails for variations and changes in hardness offers a satisfactory method for observing changes in nails following administration of substances, dietary or otherwise. Moreover, the correlation between changes in hardness and both observed improvements and the subject's expression of improvement is extremely good and lends support to the use of the technique we have developed and described for measuring changes in the hardness of fingernails.

The mechanism by which gelatin increases the hardness of fingernails is not well understood. Our data suggests that gelatin exerts a specific effect rather than a general effect on fingernails, possibly through both metabolic functions involving amino acids and through its specific dynamic action (SDA).

As suggested by Schwimmer and Mulinos (5), gelatin could increase the presumably diminished blood flow at the nail bed through its SDA. The thermogenic effect of SDA has been demonstrated by several investigators through the use of individual amino acids (8). It has been shown that a 5% solution of glycine was more effective than a 5% solution of glucose in

delaying the onset of a lethal hypothermic state and enhancing the rewarming rate in hypothermic dogs (9). This effect has been attributed to the SDA of glycine; and since gelatin contains more than 26% glycine as well as other amino acids with a high SDA, this may explain in part the effect of gelatin. Our data (Table 1) show a variation in the hardness and changes in hardness of the individual nails of any one subject. From the point of view of the use of the fingers, certain fingers being subjected to more use and mechanical pressures than others, peripheral circulation becomes an extremely significant factor, and any effect on peripheral circulation would, in our opinion, exert an influence on the state and condition of fingernails.

The fact that gelatin may be functioning *via* metabolic activities can be demonstrated through the work of Rosenberg, *et al.* (3 and 4), who obtained evidence for nail improvement after administration of gelatin for several weeks, in a time too short for complete growth of nails. Godwin (10), using S^{35} labeled cystine, found the presence of considerable quantities of cystine in the claws of rats within one to two hours following administration. Borsook (11) has shown that, following the ingestion of a single dose (87 g.) of gelatin, there was not only an increase in energy metabolism but also an increase in the excretion of urinary nitrogen, sulfur, and uric acid. Moreover, fingernails have been reported to contain all their amino acids in similar molecular proportion to gelatin except for cystine, of which nails contain approximately 219 times more than gelatin (12). Furthermore, pure cystine, when fed to patients with nail defects, failed to improve their nails (13).

It is well established that an increase in the rate of protein (amino acid) metabolism causes a simultaneous increase in the rate of metabolism in general. Although the basis of this phenomenon is complex it seems probable that a partial explanation can be found in the relationship between amino acids and the reactions of the tricarboxylic acid cycle. For example, flooding the liver with a mixture of amino acids causes a marked increase in the amounts of pyruvic, oxaloacetic, and alpha-ketoglutaric acids (*via* deamination and oxidation mechanisms) which, through mass action, tend to increase the rate of cycle oxidations. Since high energy ATP is needed for the synthesis of proteins from amino acids, there is an increased demand for ATP for tissue protein synthesis under these conditions, and this demand could be met by an increased rate of ATP formation in the speeded up tricarboxylic reactions. Thus, the ingestion of gelatin (high amino acid concentration) would result in increased ATP formation and subsequent protein synthesis.

Similarly, the ingestion of lactose, which gives rise to glucose and galactose, could increase cycle oxidations, thus accounting for the initial increase in the hardness of the fingernails of test subjects on the placebo

regimen at the end of one month through utilization of body amino acids for this purpose. However, the continuing effect of gelatin in producing an increase in the hardness of fingernails, when compared to the observed effect of lactose, could be explained through the fact that gelatin is providing amino acids of a specific nature, thus suggesting a function of gelatin other than a general source of amino acids.

The rapid rate of response to gelatin observed in our work, one month of gelatin regimen resulting in a significant increase in the hardness of most all of the nails in five out of seven subjects, again supports the concept of a specific effect of gelatin despite the fact that in all probability all the amino acids contained in gelatin are ingested in ordinary daily diets. This is particularly significant in view of the dose administered, 2.0 g. per day. Additional studies using even lower doses of gelatin would shed light on this specific effect of gelatin. It is also interesting to note that with continued intake of 2.0 g. of gelatin there is a continuation of gelatin's effect on the hardness of nails. The data suggests that this effect is specific and constant. With continued gelatin administration the net gain in hardness increases monthly. The significance of this observation is not evident at this time. Only further studies on a time-dosage basis would establish whether this increase in hardness would continue in a linear fashion or would plateau to a constant value in terms of hardness related to the dosage being administered.

Summary and Conclusions

Data has been accumulated which indicates that the daily ingestion of 2.0 g. of gelatin increases significantly the hardness of fingernails and apparently improves nail defects in normal subjects.

Observations made show that the response of the fingernail to gelatin, as measured by changes in hardness, occurs within one month following ingestion of gelatin on a daily basis in five out of seven test subjects. A slight increase in the hardness of the nails of subjects on the placebo capsule regimen was observed, although no improvement in apparent nail defects was obtained.

The use of the technique of measuring the hardness of fingernails as a tool for evaluating the effects of gelatin (or other substances) is discussed.

The results are discussed in terms of a "specific" action of gelatin with the effect of gelatin on fingernails occurring through either specific dynamic action or metabolism of the amino acids inherent in gelatin.

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FRICTIONAL EFFECTS IN HUMAN HAIR

By Anthony M. Schwartz, Ph.D.,
and D. C. Knowles, Jr., M.Sc.*

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Abstract

The static and kinetic frictional coefficients of hair are among the most important factors affecting combability and softness and are good measures of hair condition. Preferred methods are described for measuring the friction of hair against itself and against a variety of hair device materials. They include the static mandrel method for single fibers and the capstan method for multiple fiber tapes and tresses. Hair friction is influenced by many different factors, each of which must be carefully controlled in making meaningful measurements.

The effects of these various factors are illustrated and discussed. Two of the more important among them are the degree to which the hair keratin has been modified chemically and the burden of adsorbed surfactant which the hair carries as a result of its shampooing history. The relationships among the type and content of adsorbed surfactant, hair condition, hair friction and hair combability are described quantitatively.

Introduction

From the cosmetic point of view, hair friction is of importance in at least three different connections:

1. After shampooing, but before drying, it is a widespread practice to comb out the wet hair. It is recognized that some shampoos make this wet combing operation difficult, whereas others make it easy. The friction of both hair-on-hair and hair-on-comb enters into this effect. To a much lesser extent, the problem of difficult combing is also encountered with dry hair.

2. The softness or "hand," or "condition," of dry hair, as judged by feeling it, depends on the friction encountered as the individual fibers rub over one another. This is a well-recognized effect in textile fabrics, as well as in the hairdressing art.

3. In a less obvious manner, friction influences the over-all manageability of hair. It is closely related to the adhesion which exists to varying degrees among individual fibers and also to static electrification. Both of these effects contribute to manageability, although other factors such as the presence of free liquid material on the hair can also have a large influence.

* Harris Research Laboratories, Inc., Washington 11, D. C.

One of the purposes of the work described herein was to develop satisfactory methods for measuring the friction of human hair, both against itself and against the various materials used to fabricate hairdressing devices such as combs, rollers, etc. A further purpose was to investigate quantitatively the various factors that determine hair friction and to determine their relative importance. Emphasis was placed on the effect of various shampooing treatments and topical applications.

Measurement of Friction

The classical law of friction, which is valid within relatively wide limits, states that the force necessary to cause sliding of one smooth solid surface against another (the frictional force) is proportional to the normal force or "load" pressing the two surfaces together and is independent of the area of contact. The proportionality constant is called the coefficient of friction and is frequently designated by the Greek letter μ. The force just necessary to start sliding determines the static coefficient (μ_s), and the force necessary to maintain sliding after it has started determines the dynamic or kinetic coefficient (μ_k). Unless otherwise stated, data in the attached tables are values of μ_k measured in the moderate speed range where the variation of μ_k with speed is very slight.

Friction is affected by lubricant materials that may be present between the rubbing surfaces. The present work deals primarily with unlubricated or "dry" friction systems. In cases where surface layers of foreign matter were present on the rubbing surfaces, they acted at best as boundary lubricants (which can be treated by the laws of dry friction) rather than as hydrodynamic lubricants. Friction is also closely related to adhesion. In none of the systems described was the adhesion (i.e., the force of attraction across the boundary plane between the two surfaces) sufficiently great to form a typical adherent system, i.e., one in which the surfaces become grossly distorted or damaged during sliding or separation.

The friction of textile fibers has been studied by many investigators, and several different instrumental methods of measurements have been described (1). After preliminary experiments with several methods, it was decided to adapt the method of Roeder (2) to the measurement of human hair friction. This is essentially a dynamic method for measuring the friction of a single fiber on a bundle of similar fibers. It can be used for static friction measurements, however, and can be modified for use with tresses or tapes of hair and for measurements of hair friction against solid nonfibrous substrates.

The apparatus is shown in diagram form in Fig. 1. M is a cylindrical mandrel whose surface is composed of the reference material. H is a single hair fiber, weighted at each end with equal weights, W and W_1. T is a torsion balance, the pan of which (P) is set under W_1. The mandrel is

started revolving at uniform velocity in the direction of the arrow. W_1 starts to push down on P, and the dial of T is then adjusted so that the balance arm is in the equilibrium position. The frictional force required to maintain this equilibrium while the mandrel is moving is $W-(W_1-R)$ where R is the dial reading on the torsion balance. From these data the coefficient of friction can be calculated. The area of contact between H and M does not enter into the calculation of frictional coefficient and need not be measured.

The calculation is based on a formula used by engineers for belt-driven pulleys (3). In this case, where the angle of encirclement is 180°, the formula is:

$$\mu_k = \text{coef. of friction} = 0.733 \log \frac{Ms}{Mo}$$

where $Ms = W$ and $Mo = W_1 - T$.

The apparatus can be used for determining static friction by keeping the mandrel static and adjusting T until W_1 just starts to move upward.

Roeder's work involved textile fibers, which are considerably finer than human hair. For working with hair-on-hair friction, a special type of mandrel had to be designed. This device is essentially a "cylindrical zither" or squirrel cage in which about fifty individual hairs form the periphery of the cylinder, as shown in Fig. 2. A and B are the two sections of the cylinder, each about $^1/_2$ inch in diameter. Section A is threaded axially to take the adjusting screw S. S serves to adjust the tension on the hairs H. Section B is fitted with a stem C which is held in the chuck of the driving mechanism. The hairs H are evenly spaced about 1 mm. apart and are cemented to A and B by the cement layers D. A du Nuoy tensiometer is used as the torsion balance. The torsion arm of the balance as well as the driving mechanism for the mandrel are so arranged that measurements can be made under water to obtain wet friction.

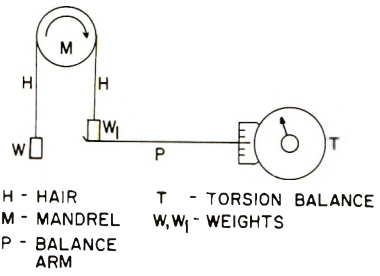

Figure 1.—Schematic view of friction apparatus.

For hair-on-comb friction cylindrical mandrels of the comb material are used.

The friction of individual hair fibers can vary widely (up to 30 or 40%) even among hairs from the same lot. It is often convenient to get an average value by using a tape composed of well arrayed hairs rather than a single fiber. In this method a heavier mandrel and sturdier balance

must be used. For an average hair-on-hair friction, the hair tape may be run against a well arrayed tress of similar hair which has been wrapped around the mandrel.

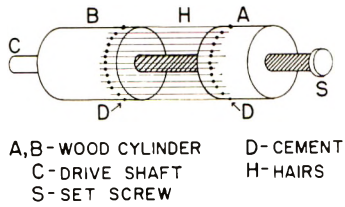

Figure 2.—Perspective view of mandrel with hair in place.

Directional Effects and Other Variables in the Measurement of Hair Friction

A. The Directional Effect

It is well known that animal hairs show different frictional values depending on whether the hair is rubbed "with the grain" of the scales (R–T = root to tip) or in the opposite direction (T–R = tip to root). If we consider two hairs lying adjacent and parallel (Fig. 3), it is apparent that there are three different friction values possible. In diagram A the scale edges of only one of the fibers is rasping, no matter what the direction of relative motion. In B, neither set of scales is rasping, and the friction is lower than in A. In C, both sets of scales are locking, and the friction is higher than in A. If we have the hairs perpendicular to one another, there are only two possible friction values: with and against the scales, as shown in D and E. All cases of sliding hair-on-hair friction can be resolved into the components represented by these five diagrams.

In practice, where the root ends are all anchored in the scalp, it is

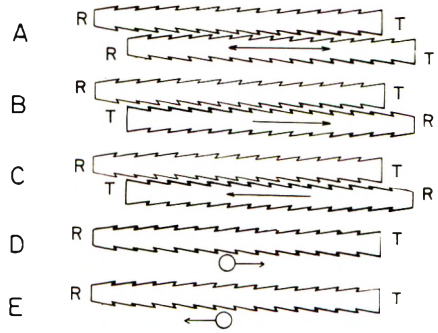

Figure 3.—Directional effects in hair friction. Top hair stationary, bottom hair moving.

apparent that case C will not often be encountered. In combing, cases D and B will be most important. With regard to softness and manageability, cases A and E may also enter the picture. Unless otherwise stated, all tabulated measurements were made in the direction of lowest friction.

B. Other Factors Affecting Friction

1. *Load.* Although the classic law of friction states that the coefficient of friction is independent of the normal load (within wide limits), it is an experimental fact that the μ_k value of most friction systems involving fibers tends to increase substantially at very light loads. It is fairly constant, however, at high loads. Preliminary experimentation indicated that hair behaved like other fibers in this regard, and most measurements were made in a range where the load *vs.* μ_k curve was substantially flat.

2. *Velocity.* Relative velocity of the two rubbing surfaces has little effect on the value of μ_k in most dry or boundary lubricated systems, although it has a major effect in hydrodynamically lubricated systems. There is frequently a sizable difference, however, between μ_k (at any velocity) and μ_s, the static coefficient of friction. This latter quantity can be measured directly by measuring the force necessary to start movement. It can be measured indirectly by extrapolating back to zero velocity the measured values of μ_k at progressively lower speeds. Unless the extrapolation is done very painstakingly, the two values will frequently disagree. In the present discussion we shall limit ourselves to values of μ_k measured in ranges where the curve of velocity *vs.* μ_k is substantially flat.

3. *Physical and Chemical Nature of the Rubbing Surfaces.* Since friction is a manifestation of interaction at the solid-solid phase boundary and is strongly dependent on the free energy of the interface, it is to be expected that μ_k will be a characteristic property of the pair of rubbing surfaces. Changes in the surface of either rubbing element will, in general, change the friction. Surfaces of all solids, including those that are essentially nonswellable and impermeable, can be altered by the presence of adsorbed monomolecular layers or by the presence of imperceptible coatings of multimolecular thickness. These latter coatings, as well as the monolayers, may be continuous or patchy. The surface properties, and therefore the friction, of hair can be modified by several additional factors: (a) Moisture content has a considerable effect on hair friction. Consequently, measurements should be at controlled humidity and temperature. Wet measurements are preferably made under the liquid medium after the hair has had a chance to equilibrate completely. (b) State and degree of modification of the keratin substance composing the hair affects friction, and also affects the response of hair friction to moisture. (c) The presence of soluble materials sorbed from solution, but not necessarily present as a surface coating, can affect hair friction. The most important substances

in this category are the surfactants present in shampoos, creme rinses and other hair care preparations. It is with the effects of these substances that the present study is primarily concerned.

Values of μ_k in dry or boundary lubricated systems seldom fall outside the range of about .05 to 1.0; i.e., there is only about a 20-fold difference between a highly slippery system and one that tends to grip or bind

Results and Discussion

Effect of Various Substrates

Table I shows the μ_k values of hair on itself and on six smooth specimens of solid materials typical of those used in combs and hair devices. The hair was unmodified and was cleaned prior to testing by shampooing twice in 2% triethanolamine lauryl sulfate (TEALS) and rinsing thoroughly. The test mandrels of the solids were also washed in TEALS and rinsed.

Table I—Typical Dynamic Friction Values (μ_k) Hair on Smooth Solid Surfaces*

	Lucite‡	Alumi-num‡	Glass‡	Nylon‡	Poly-ethylene‡	Hard Rubber†	Hair-on-Hair†
Dry	0.19	0.12	...	0.14	0.22	0.19	0.15
Wet	0.45	0.18	1.4	0.22	0.29	0.38	0.34

* Unmodified hair, 2% TEALS wash + two 2 minute rinses.
† Single fiber values averaged.
‡ Tapes of hair used.

It is evident that the wet friction is, without exception, higher than the dry friction. In some instances, notably aluminum and the particular sample of polyethylene used in this test, the difference between wet and dry friction is small. In other cases, such as lucite and hard rubber, it is quite large. Most noteworthy is the wide variation in μ_k among the various solids, particularly in the wet systems. There is almost a three-fold difference between aluminum and Lucite and an eight-fold difference between aluminum and glass. The friction of clean wet glass against clean wet hair, 1.4, is unusually high. Identical combs were made of the six materials listed in Table I and were used to comb wet, unmodified hair (both in tresses and on heads) that had been shampooed with TEALS. The rating of the various combs with regard to ease of combing correlated completely with the friction values.

Effect of Shampoo Treatments

Table II shows the effect of different shampooing treatments on the friction of unmodified hair against itself. The data for the first part of this table were obtained by shampooing and measuring 12 individual fibers and averaging the friction values. These same fibers were then shampooed in the next test bath until they had attained their new equi-

TABLE II—TYPICAL DYNAMIC FRICTION VALUES*

	Alcohol†	ABS†	TEALS†	Soap†	CFA-DEA‡	TEALS‡	Commercial‡ Shampoo 1	Commercial‡ Shampoo 2	Commercial‡ Shampoo 3	Commercial‡ Shampoo 4
Dry	0.12	0.15	0.12	0.11	0.24	0.21	0.18	0.20	0.17	0.18
Wet	0.20	0.23	0.19	0.15	0.36	0.27	0.28	0.26	0.24	0.22

* Unmodified hair-on-hair. Effect of shampooing treatment.
† Individual fibers—calibrated hair technique.
‡ Tresses.

librium friction value, measured and transferred for treatment to the next test bath, etc. The data columns (1–4, marked "†") show that the shampooing has a considerable effect. The highest friction was obtained by shampooing with sodium dodecylbenzene sulfonate (ABS) and the lowest by shampooing with soap. The first treatment given the original soap-washed fibers was a thorough series of washes in ethanol. This produced a wet friction level of 0.20, which was raised to 0.23 by the ABS treatment. The second part of Table II shows the friction of unmodified hair tapes on tresses from the same hair lot after equilibrating in two typical surfactant ingredients of shampoos and four different commercial shampoos. The differences among the commercial products are statistically significant, and two of these materials give friction values lower than straight TEALS. An unexpected result is the high friction resulting from shampooing with straight coco-fatty diethanolamide, CFA-DEA, (1-to-2 molar ratio) detergent.

Effect of Hair Modification

The difference in wet dynamic friction between unmodified hair, hair waved twice by a typical cold waving process, and hair bleached to a medium blond after being twice waved, is shown in Table III. Bleaching (by a typical ammonia-peroxide process) on top of strong waving raises the friction on all substrates to high levels, whereas waving alone has a relatively slight effect. Table IV shows the strong effect of a single cationic creme rinse treatment in lowering the wet friction of shampooed bleached-waved hair. It is noteworthy that the creme rinse was applied only once, in a conventional manner, and the hair was not equilibrated with either the

TABLE III—TYPICAL WET DYNAMIC FRICTION VALUES. EFFECT OF HAIR MODIFICATION*

	Unmodified	Waved	Bleached-Waved
Hair-on-hair	0.25	0.31	0.49
Hair-on-Al	0.20	0.23	0.35
Hair-on-Lucite	0.43	0.50	0.71

* All values at comparable measuring condition.
TEALS shampoo.

TABLE IV—TYPICAL DYNAMIC FRICTION VALUES*

	Hair-on-Hair		Hair-on-Al		Hair-on-Lucite	
	Dry	Wet	Dry	Wet	Dry	Wet
Commercial Shampoo No. 1	0.14	0.49	0.10	0.26	0.18	0.67
Same followed by Creme Rinse	0.13	0.30	0.10	0.17	0.15	0.27

* Effect of treatments on bleached-waved hair.

cationic surfactant or the auxiliary materials present. It is also of interest that the creme rinse had relatively little effect on the dry friction. The fact that creme rinse greatly facilitates the wet combing of highly modified bleached and bleached-waved hair is well known and correlates with the quantitative friction values.

Effect of Hair History

In general, a new shampoo treatment will cause a change in hair friction. Sometimes a drastic change can occur with just one application of the new treatment. More often, however, the ultimate effect of the new treatment is not attained until it has been applied several times. The effect on friction of a typical sequence of treatments is shown in Table V. The hair in this test was first washed several times in sodium dodecylbenzene sulfonate (ABS). Its friction after this treatment is shown in the first row of the table. A single conventional treatment with creme rinse brought the friction down very substantially and made the tress much easier to comb. The hair was then shampooed once with ABS, whereupon the hair-on-hair friction became even lower. At the same time, the hair-on-Lucite friction increased to its original value, probably because the ABS removed all residual creme rinse from the Lucite in the single application. After three shampooings

TABLE V—EFFECT OF SUCCESSIVE TREATMENTS ON HAIR FRICTION

Treatments (in order)	Hair-on Hair		Hair-on Lucite	
	Friction μ_k	Wet μ_s	Friction μ_k	Wet μ_s
ABS Washed	0.35	0.30	0.52	0.55
Creme Rinse	0.26	0.20	0.39	0.41
ABS Washed 1X	0.19	0.16	0.49	0.55
ABS Washed 3X	0.36	0.29	0.51	0.56

TABLE VI—EFFECT OF CHANGING SHAMPOOS ON FRICTION
Wet Hair-on-Hair μ_k Values

	Pattern A	Pattern B	Pattern C
Shampoo X Equil.	0.25	0.25	0.25
Shampoo Y 1X	0.27	0.23	0.36
Shampoo Y 2X	0.30	0.27	0.34
Shampoo Y 3X	0.31	0.30	0.33
Shampoo Y 4X	0.32	0.32	0.32
Shampoo Y Equil.	0.32	0.32	0.32

with ABS, the hair-on-hair friction, as well as the hair-on-Lucite friction, was back to the original value.

Neglecting the extreme effect of creme rinse, and simply changing from one shampoo X to another shampoo Y having a different ultimate frictional effect, several types of transition have been noted. These can best be illustrated with specific values, as follows: Consider that shampoo X has an equilibrium μ_k value, wet hair-on-hair, of 25, and shampoo Y a corresponding of 32. If we take a tape-tress combination equilibrated with X and start shampooing with Y, we may get any of the three patterns illustrated in Table VI. Pattern A is considered normal. Patterns B and C have been noted in cases where the two shampoos differ greatly in pH and contain components such as fatty acids or anionic-cationic complexes, which are markedly susceptible to pH changes. These patterns are not uncommon where the ionic types of surfactant in the two shampoos differ. It is noteworthy that patterns of the B or C type can give the consumer a false first impression of the long-term performance of her new shampoo.

Summary

Measurements of hair friction can furnish a very revealing picture of the state of the hair surface. They must be interpreted carefully and made with full control over the numerous parameters that determine the numerical values of the frictional coefficients. Both the physicochemical state of the hair keratin and the shampooing history of the hair, as well as the presence of superficial films, are among the important factors influencing hair friction. Friction measurements correlate very well with subjective judgments of handle and combing ease and can be used advantageously in the development of shampoos, rinses, and other topical hair treatments.

(Received April 17, 1963)

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(1) H. G. Howell, K. W. Mieszkis and D. Tabor, *Friction in Textiles*, Textile Book Publishers, Inc., New York, 1959.
(2) H. L. Roeder, *Physics of Fibrous Materials*, Symposium of Dutch Physical Society, Arnhem, The Netherlands, 1950.
(3) *Mechanical Engineer's Handbook*, edited by Colin Carmichael, 12th Ed., 7th Printing, John Wiley & Sons, New York, 1950, pp. 15–44.

SURFACE CHEMISTRY, Theory and Industrial Applications, by Lloyd I. Osipow. Reinhold Publishing Corp., New York. 1962. American Chemical Society Monograph 153, 459 pages, indexed. Price $13.50.

This collection of related essays on the chemistry of surface active agents is a remarkable testimony to the breadth and variety of interests developed in the intensive, serious and competent study of detergents in a commercial laboratory. It ranges over the chemistry of surfactants and the basic theoretical chemistry of this field but does not extend to other fields of surface chemistry. The book is in many ways an interesting one, and the author's general clarity of presentation makes it pleasant and often stimulating reading.

In the interests of not confusing the reader the author arbitrarily selected for discussion those ideas which appeared most credible, rather than present conflicting interpretations. This point of view is tenable for many classes of technical exposition, but it removes the book from the generally accepted definition of "monograph" (which is stated in the General Introduction prefacing this and other members of the ACS Monograph series) and may, indeed, disappoint readers who anticipate a monograph treatment.

It would be too much to expect that a single review of surfactant chemistry, of less than 500 pages, would, for the cosmetic chemistry laboratory, make any significant contribution to the literature of surfactant chemistry of interest to cosmetic science—and no such expectation is realized here. The chapter on emulsions certainly cannot replace any of several good discussions on this subject which are readily available and already on the shelves of almost all cosmetic chemistry libraries. The scanty literature of cosmetic detergency is not cited or discussed in the chapter on detergency, which, indeed, only discusses some of the more recent and elegant work in textile and fiber detergency. The outline of surfactants (Chapter 8) is rudimentary and too limited to be of value in the cosmetic chemistry laboratory.

The earlier chapters, dealing with theoretical surface chemistry and fundamental physical chemistry, are concise outlines, serving as brief refreshers prior to the later chapters but with insufficient development to serve as an introduction to fundamental surface chemistry. This conciseness gives an episodic character to this section. Indeed, there is sometimes a lack of concordance, as when, in the first chapter, an equation stating the numerical equivalence of surface tension to specific surface free energy is characterized as a "fundamental relation of surface chemistry," while in Chapter 10 this numerical equivalence is termed merely a common assumption, and, from newly stated definitions of the two quantities, this later discussion proceeds to develop a different equation relating them.

The abundance of typographical errors is unfortunate and even much

greater than the large number to which present day publishing laxity has accustomed us. Proofreading did not catch some annoying misstatements; one, for example, causes the reader to wrestle overly long with a text that incorrectly describes the graphic presentation of the relationship of conductivity of a Teepol solution to its content of octyl alcohol.

"Surface Chemistry, Theory and Industrial Applications" offers an opportunity to review generally clear and well-written expositions of many facets of the chemistry of surface active agents. The author merits commendation for this achievement. Excellent as it is this in respect, however, the book is not a monograph on surface chemistry (nor the chemistry of surface active agents), nor is it an adequate treatment of the title subject for the purposes of the cosmetic chemistry laboratory.—J. M. LONGFELLOW, Colgate-Palmolive Co.

ENZYME HISTOCHEMISTRY, by M. S. Burstone. Academic Press, New York, N. Y. 1962. 621 pages, indexed and illustrated; price $22.50

The structure and function of skin has become, in recent years, a major preoccupation of the cosmetic chemist. It is now generally recognized that genuine improvement of cosmetic products must be based primarily on improved knowledge of the effects of such products on the skin.

The enzymes of skin have received considerable recent attention, and future studies of the effectiveness of many cosmetic preparations will undoubtedly include determinations of their effect on various enzyme systems. It is therefore proper that Dr. Burstone's treatise be reviewed in this journal.

The author points out that, at the end of the second World War, only two or three histochemical enzyme procedures were available. His book sets forth in highly systematic fashion a truly remarkable array of methods and reagents for detecting large numbers of enzymes by production of colored substances in tissue sections treated with fully described special reagents.

After this thorough treatment of techniques for fixing and embedding tissues, there is a general description of naphthol derivatives used in histochemistry. The laboratory synthesis of Naphthol AS compounds is described, and a list is given of commercially available Napthol AS derivatives. Diazonium salts are similarly treated.

The matter of substantivity and histochemical localization also receives adequate explanation. Metal dye complexes and mounting media are also covered.

The enzymes recognizable by histochemical procedures are treated according to standard groupings. In each chapter, one appendix describes the synthesis of special substrates needed, and another describes in detail the techniques used for detecting individual enzymes. Electron-microscopic methods and electrophoretic procedures for enzyme detection also receive brief discussion.

In an age of specialization, this book is surely unique in being a do-it-yourself treatise on a highly specialized discipline. Both the histology and the synthetic organic chemistry involved in the various procedures are so well described as to seem relatively simple.

The book is well printed and is profusely illustrated with very clear photomicrographs. Several color plates are included, giving especially good examples of the contrasts and detailed structure visible by histo-

chemical methods.—PAUL G. I. LAUFFER.

RECENT PROGRESS IN THE CHEMISTRY OF NATURAL AND SYNTHETIC COLOURING MATTERS AND RELATED FIELDS, edited by T. S. Gore, B. S. Joshi, S. V. Sunthankar and B. D. Tilak. Academic Press, London. 1962. Price $24.

This commemoration volume is a collection of 49 excellently documented, original papers dedicated to Professor K. Venkataraman on the occasion of his sixtieth birthday. No less than 86 workers in the field (former students, collaborators and colleagues of the distinguished Indian dye chemist) have joined in this unusual tribute.

Although most of the papers are concerned with *colored* compounds, the color aspect is obviously not always of primary interest to some of the investigators. As a result, the collection is both fascinating and bewildering at times, covering many fields apparently unrelated to the main title subject. It is a veritable *potpourri*, with a number of the papers having direct or peripheral interest to the cosmetic chemist. Nine of these are briefly summarized below:

Ommochromes (A. Butenandt and W. Schafer); among the most widely distributed pigments in the animal (insect) kingdom, the ommochromes are the final product of tryptophane metabolism.

Recent Developments in the Carotenoid Field (O. Isler, R. Ruegg and P. Schudel); isolation and synthesis of intermediates in carotenoid biogenesis, commercial syntheses and use of carotenoids in food coloring are discussed.

Azulenes from Natural Precursors (S. Dev); the chemistry and sources of about 50 of these non-benzenoid aromatics are discussed. There is no mention of the pharmacologic-dermatologic virtues which have occasionally been ascribed to this class of compound.

Naturally Occurring Phloroacylophenones (W. Riedl); this section includes some which have been used as anti-helmintics and silk dyes since antiquity.

Some Naturally Occurring Black Pigments (R. H. Thomson); these are generally polymeric oxidation products of phenols (catechols, 1,8-dihydroxynaphthalene, etc.) conjugated with protein or carbohydrates. A considerable discussion of melanins is also included in this paper, as well as the dark glucoside plant pigments.

Some Natural Anthraquinone Colouring Matters (B. S. Joshi); the discussion ranges from the antimicrobial properties of teak wood and Cape aloe extracts to use of *Cassia obtusifolia* seeds, to *aspergillus* mold pigments, to shellac coloring matter.

Naturally Occurring Phenylcoumarins (N. R. Krishnaswamy and T. R. Seshadri); an excellent review of the chemical and biological properties of this large group of compounds is given. Their activity ranges from antibiotic to estrogenic to insecticidal. Included are discussions of brazilin, haematoxylin, mammeisin, coumestrol and psoralidin.

Chemistry of Polyene Antibiotics (D. S. Bhate); almost all of the 60 known polyenes have high antifungal activity (including *vs.* yeasts) but little or no activity against bacteria. Most are derived from *streptomyces* spp. Nystatin (the first polyene antibiotic), Hamycin and Amphotericin B are examples of this group.

Dyestuffs Containing Vinylsulphone Groups (J. Heyna); these are among the so-called "fiber reactive"

dyes which have been introduced in the past ten years. They react chemically with wool; bifunctional vinyl sulfones can crosslink and therefore harden proteins, e.g. gelatin.

Also of interest to the cosmetic chemist are numerous other papers in this collection, covering such diverse subjects as the logwood dyes, true vegetable dyes, quercitins and other flavones, carminic acid, diterpenes, vanillin, bixin, quinonoid dyes and optical whitening agents.—ROBERT L. GOLDEMBERG, Shulton, Inc.

AUTOXIDATION AND ANTIOXIDANTS, Vol. II, by W. O. Lundberg. Interscience Publishers, Division of John Wiley & Sons, New York, London. 1962. 706 pages, indexed and illustrated.

While Vol. I deals primarily with the fundamental chemistry involved, Vol. II applies the fundamentals to the preservation of foodstuffs, fats, oils, petroleum, rubber, soaps, cosmetics and pharmaceuticals. There is an excellent chapter on the autoxidation of fatty compounds in living tissue and biological antioxidants.

Fifteen authors, highly specialized in their fields, contribute ten chapters, covering the entire area of antioxidants and their application.

There are four chapters relating to rancidity in foods and food products. Here, detailed discussions as to the nature of the rancidity and its measurement by analytical procedures, together with information toward preventing it, are presented.

Antioxidants suitable for use in foods are listed, covering their history, characteristics, selection and determination. Both hydrolytic and oxidative rancidity relating to meats, dairy products, cereals, mayonnaise, grains, vegetables and miscellaneous items are discussed.

Flavor reversion and related deterioration include the causes, taste panel analysis, effect of metals, fractionation, deodorization and hydrogenation.

There are five excellent chapters that cover the subjects of oxidative polymerization, driers, petroleum, rubber and high polymers. Products such as printing inks, antiskinning agents, metallic driers, organic driers, gasoline, jet fuels, rocket fuels, lubricants, waxes, etc., are given ample consideration. Lists of available antioxidants, patents and literature references are also presented.

The chapter pertinent to cosmetic chemists is that covering the stability of the vitamins, soaps and cosmetics, pharmaceuticals, essential oils and other related products. Also of interest to the cosmetic chemist is the final chapter dealing with living tissue fatty compounds together with enzyme activity and vitamin destruction.

Each chapter is furnished with numerous literature and patent references. This volume is an excellent up-to-date practical treatise on the subject of autoxidation and antioxidants and would be a valuable addition to the library of both the theoretical and product development chemist.—JAMES H. BAKER, Gar-Baker Laboratories, Inc.

NOTICE TO S.C.C. MEMBERS

Many members of the Society have requested that a complete roster of their fellow-members be made available.

Such a membership list is now in preparation and, it is hoped, will be published in one of the 1964 issues of the Journal.

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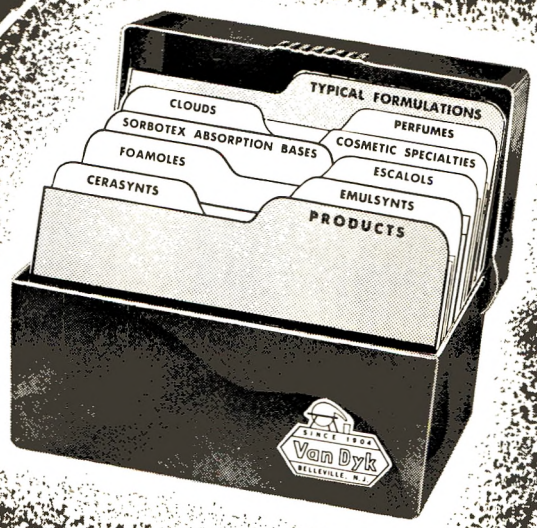

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