Hair and Scalp Diseases

Medical, Surgical, and Cosmetic Treatments

Edited by **Amy J. McMichael** and **Maria K. Hordinsky**

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Hair and Scalp Diseases

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We could not have done it without you!

—Amy J. McMichael
Maria K. Hordinsky

Series Introduction

During the past 30 years, there has been a vast explosion in new information relating to the art and science of dermatology as well as fundamental cutaneous biology. Furthermore, this information is no longer of interest only to the small but growing specialty of dermatology. Clinicians and scientists from a wide variety of disciplines have come to recognize both the importance of skin in fundamental biological processes and the broad implications of understanding the pathogenesis of skin disease. As a result, there is now a multidisciplinary and worldwide interest in the progress of dermatology.

With these factors in mind, we have undertaken this series of books specifically oriented to dermatology. The scope of the series is purposely broad, with books ranging from pure basic science to practical, applied clinical dermatology. Thus, while there is something for everyone, all volumes in the series will ultimately prove to be valuable additions to the dermatologist's library.

The current volume represents what I believe to be the definitive work on the management of hair and scalp disorders by recognized authorities in the field. It should prove to be a valuable resource for clinicians, students, and educators in dermatology.

Alan R. Shalita, M.D.
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Department of Dermatology
SUNY Downstate Medical Center
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Preface

Our goals were several in developing and editing *Hair and Scalp Diseases: Medical, Surgical, and Cosmetic Treatments*. First, we wanted to give the readers of our text a comprehensive view of treatment for each scalp and hair disorder. Rather than follow previous models, we strove to create the quintessential text on treatment of these disorders with a special concentration on ethnicity, hair type, and cultural haircare practices for each entity in a composite fashion. We wanted to impart widely the information that has been accumulated by specialists in the field of hair and scalp disorders and to do so in a way that was easy to follow, practical, and complete. Finally, we strove to enumerate treatments that may go beyond accepted U.S. and international guidelines and incorporate off-label use of medications when data indicates this may be necessary.

We charged our contributors with the challenge of approaching each hair disorder with a therapeutic ladder. The treatment of each disorder begins in the simplest form and becomes more complex, dependent upon patient response, cultural practices, and concomitant disease. We asked each author to create treatment plans that look beyond the best-described treatments to those that incorporate creative, thoughtful approaches to the management of the multitude of hair and scalp disorders that challenge dermatologists. While physicians must be savvy about product inserts for recommended dosage schedules, we asked our contributors to consider how practical and effective treatment may differ from package inserts or must be altered to allow for treatment of a wide range of patients with different hair types.

We asked authors to report how the treatments that they chose worked, including mechanism of action, absorption characteristics, and general pharmacology of the agent or agents. We felt this was imperative for both cosmetic, nonprescription, and prescription agents. To make this text current, we asked authors to include data on the efficacy or benefits of many of the latest product additives. We felt that the phenomenon of allergic responses of scalp skin and the appropriate agents to use in the face of suspected or known sensitivities is important, but often overlooked. This book serves as a primer for those seeking an approach to the patient with irritant and allergic contact dermatitis reactions of the scalp. With all this in mind, our authors were asked to include all ethnicities and hair types when discussing choice of treatment and product efficacy. We specifically hoped to avoid creating a separate ethnic haircare chapter by requesting that each contributor integrate this information into each of their chapters, where diversity in approach can be appreciated and put into perspective.

The audience for this work is wide. Practicing dermatologists and dermatologists in training will find the therapeutic regimens presented here to be practical and helpful. Staff in pharmaceutical and cosmetic companies can benefit from understanding the dermatologist's approach to the diagnosis and management of hair and scalp disorders. We firmly believe that anyone interested in hair and scalp diseases will benefit from using this book as a resource.

Amy J. McMichael
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1 Human Hair

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INTRODUCTION

As the fifth and naked ape, modern humans do not possess an all-encompassing, thick and pigmented pelage once the intrauterine lanugo hairs are shed. Selection for shorter and finer body hair has resulted in only head hair remaining in any quantity. This however is capable of growing to greater lengths than that of any other mammal (Fig. 1).

Since the human head bears some 100,000–150,000 hair follicles, an individual adult with 30 months continuous, unstyled growth, will carry some 30 kilometers of hair. This in itself has consequences for grooming and overall appearance.

STRUCTURE OF HAIR

Many other publications describe in detail the human hair follicle (1). It is worth mentioning some of the salient features that relate to the human hair shaft. The cross section of the hair shaft has three major components: the cuticle, the cortex, and the medulla (Fig. 2). The main constituents of hair are sulphur-rich protein, lipids, water, melanin, and trace elements (2). The cortex, the main bulk of a fully keratinized hair shaft, contributes almost all the mechanical properties of the hair, including strength and elasticity (2). The cuticle consists of six to eight layers of flattened overlapping cells with their free edges directed upward to the tip of the hair shaft (2). Innermost is the endocuticle, derived from the developing cell cytoplasm contents. The exocuticle lies closer to the external surface and comprises three parts: the b-layer, the a-layer, and the epicuticle. The b-layer and the a-layer are largely proteinaceus. The epicuticle is a hydrophobic lipid layer of 18-methyleicosanoic acid on the surface of the fiber, or the f-layer. The epicuticle is not visible on routine microscopy.

The normal cuticle has a smooth appearance, allowing light reflection and limiting friction between the hair shafts. It is responsible for the luster and texture of the hair (3). The cuticle may be damaged by frictional forces (brushing, combing or blow-drying) as chemical removal of the f-layer, particularly by oxidation, eliminates the first hydrophobic defense and leaves the hair more porous and vulnerable. Cuticle disruption with alkaline chemicals is the first step in permanent hair styling (3). If the cuticle is damaged there is little change in the tensile properties of hair.

The cortex consists of closely packed spindle-shaped cortical cells rich in keratin filaments that are oriented parallel to the longitudinal axis of the hair shaft (2), and an amorphous matrix of high sulphur proteins. The intermediate filament hair keratins (40–60 kDa), comprising 400 to 500 amino acid residues in heptad sequence repeats, form hard keratin polypeptide chains that pair together to form protofilaments, which make up a keratin chain. The keratin chains have a large number of sulphur-containing cysteine residues. Cysteine residues in adjacent keratin filaments form covalent disulphide bonds, which create a strong crosslink between adjacent keratin chains (6). The disulphide bonds confer shape, stability, and resilience to the hair shaft. Other weaker bonds link the keratin polypeptide chains together, such as Van der Waal interactions, hydrogen bonds, and coulombic interactions known as salt links (6). These weaker bonds can be overcome with water (6).

The medulla consists of a cortex like framework of spongy keratin supporting thin shells of amorphous material bonding air spaces of variable size. It is absent in most human terminal hair, other than gray hairs.

FIGURE 1 Human hair grows longer than that of any other mammal.

Hair Color

Hair color is determined by the melanocytes found only in the matrix area of the follicle at the base of the cortex directly above the follicular papilla. Melanocytes transfer packages of melanin (melanosomes) to the cortical cells during anagen. Eumelanin is the dominant global pigment and confers black/brown hair. Pheomelanin, a mutation of eumelanis, is the predominant pigment found in blonde or red hair (4). Graying of hair is a normal manifestation of aging and illustrates progressive reduction in melanocyte function. The proportions of eumelanin and pheomelanin and the total amount of melanin determine the final natural color of the hair (5).

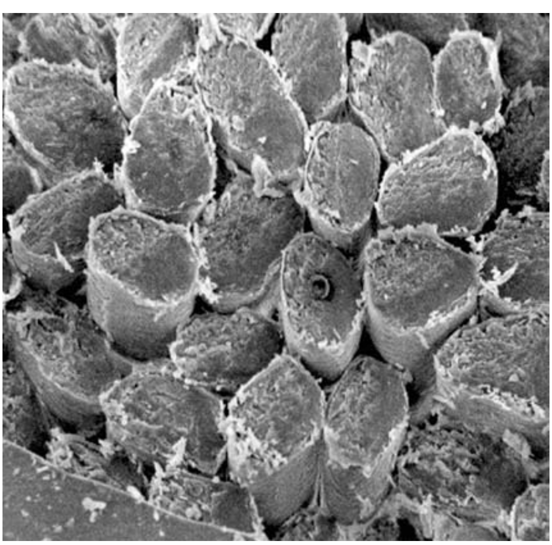

FIGURE 2 Multiple hair shafts. One hair displays a medulla.

Black and dark brown hair are the prevalent natural hair colors of peoples of all regions, accounting for more than 90% of all human hair. Dark hair is characterized by very high levels of the dark pigment eumelanin.

Blonde hair frequency is reported as 1.8% worldwide. Blonde hair is characterized by low levels of the dark pigment eumelanin and higher levels of the pale pigment pheomelanin. Shades range from light brown to pale blonde. In certain European populations, the occurrence of blonde hair is more frequent, and often remains throughout adulthood, leading to misinterpretation that blondeness is a uniquely European trait. Based on recent genetic information, it is probable that humans with blonde hair became more numerous in Europe about 10,000 to 11,000 years ago during the last ice age, as a result of Fisherian runaway mechanisms. Prior to this, early Europeans had dark brown hair and dark eyes, as is predominant in the rest of the world. In humans of many ethnicities, lighter hair colors occur naturally as rare mutations, but at such low rates that it is hardly noticeable in most adult populations. Light hair color is commonly seen in children, and is curiously common in children of the Australian Aboriginal population.

Lithuania has the highest percentage of people with blonde hair. Bleaching of hair is common, especially among women. Bleached blonde hair can be distinguished from natural blonde hair by exposing it to ultraviolet light, as heavily bleached hair will glow, while natural blonde hair will not.

There are no comparable data for red hair, but in the areas of obvious frequency (the fringes of Western and Eastern Europe) it is at a maximum of 10%. In Scotland, 35% of the population carries the recessive gene for red hair. Eighty percent of redheads have the melanocortin-1 receptor gene anomaly. Controversial estimations of the original occurrence of the red-haired gene at 40,000 years ago are probable.

Red hair is associated with the melanocortin-1 receptor, which is found on chromosome 16. Red hair may be an example of incomplete dominance. When only one copy of the red-hair allele is present, red hair may blend with the other hair color, resulting in different types of red hair including strawberry blonde (red-blonde) and auburn (red-brown).

The Record of the Hair

The hair shaft records repeated cosmetic practices—the so-called record of the hair (7). Hair grows at $\approx$ 0.4 mm per day for between two and seven years, sometimes up to 10 years (7). Newly emerging hair has properties that are different from those of the hair tips. The more distal part of the hair shaft, particularly the tip, has typically undergone several hundred washes, the application of hot styling implements, and other cosmetic procedures such as bleaching, permanent coloring, and perming in addition to normal exposure to the environment. It may show the effects of weathering. The root may be less porous and have different chemical properties (7).

MORPHOLOGY OF HUMAN HAIR

The varied morphology of humans and their hair may be explained by both genetics and the adaptive consequences that occurred after the first diaspora of *Homo sapiens*. Genetic evidence suggests that *Homo sapiens* originated only 200,000–250,000 years ago somewhere in the East African savannah. Despite their apparent phenotypic variation, today's world population is potentially derived from as few as 1,000 to 10,000 individuals. Using average rates of genetic mutation, this population lived at a time that coincided with the massive Toba volcanic disaster, which affected global climate, effectively wiped out all other hominids, and devastated *Homo sapiens*. Descendants of these "modern" humans migrated out of Africa when the climate improved and populated the earth.

The human genome is minute compared to that of other species. This is due in the most part to the gross reduction in breeding pairs in the late Pleistocene era. This core of humanity, survived near-extinction and went on to populate the entire world in less than 5000 generations. In less than 100 generations and 2000 years, world population has risen from 3 million to 6 billion. The majority (61%) live in Asia. Of the remainder, 14% live in the Americas, 13% in Africa, and 12% in Europe with only 0.5% in Oceania. Hair form arose from these clans and, as much as skin color, denotes local origins.

"Race" and Hair Form

After the first migration out of Africa the human genotype spread, localized, and adapted, to create the basic stock phenotypes still seen today (8). Despite serial migrations, the original groups have been preserved largely on a regional basis. Bands, which are the simplest form of human society, and still exist (Inuit, indigenous Australians) expanded into clans and subsequently tribes. Until the advent of global agriculture some 7,000 ago, genetic lineages were probably tightly maintained. Thereafter, gene sharing occurred on a steadily widening basis.

Where and when the emergence of the archetypal hair forms that are described in the literature occurred is not known. Similarly, knowledge of the hair phenotype of early humans and whether the tightly curled hair of today's equatorial Africa or a more wavy appearance predominated is speculative (Figs. 3 and 4).

Any given physical characteristic is generally found in multiple groups (9). Demonstrating that environmental selective pressures shaped specific physical features is difficult, since such features may have resulted from sexual selection for individuals.

Causcasoid, Negroid, and Mongoloid

The literature perpetuates the taxonomy of hair as caucasoid, negroid, and mongoloid. These terms not only have a pejorative ring but from a practical standpoint are scientifically inaccurate and no longer employed by publishers. Further, they are geopolitically incorrect. Other alternatives, such as Equatorial-African, Indo-European (IE), and Asian, might better allocate the dominant phenotypes while recognizing the impact of past passive and forced migrations, and the increasing homogenicity of the scalp hair of Homo sapiens through gene sharing.

Hair Morphology Studies

Human hair morphology varies from the flat to the round (Fig. 5). Typically these have been allocated to perceived "racial" groups (Fig. 6). However, certain human scalps often bear a multiplicity of hair phenotypes.

FIGURE 3 This woman's clan is from Eastern Africa (modern Ethiopia). Her hair displays varied phenotypic adaptability—straight hair when pregnant and tightly coiled in the nonpregnant state. Curiously she is a doppleganger for the proposed African Eve published in *Newsweek* (see Fig. 4).

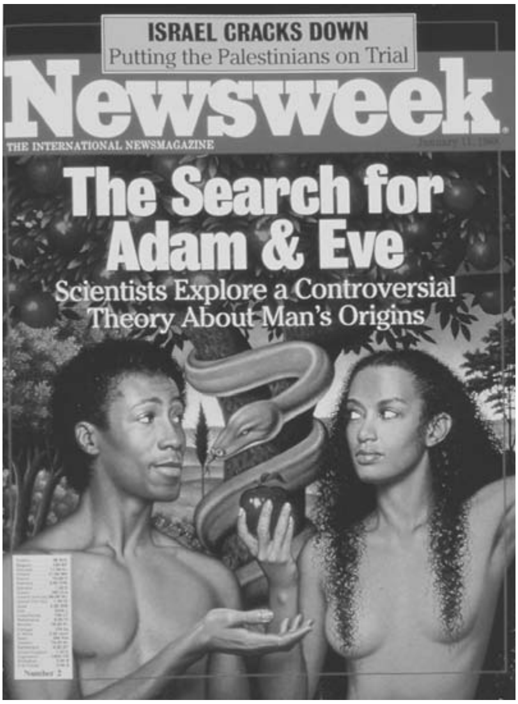

FIGURE 4 African Eve as represented in *Newsweek* magazine.

In many parts of the world, groups have mixed in such a way that many individuals have relatively recent ancestors from widely separated regions. Although genetic analyses of large numbers of loci can produce estimates of the percentage of a person's ancestors coming from various continental populations (10,11), these estimates may assume a false distinctiveness of the parental populations since human groups have exchanged mates from local to continental scales throughout history (12). Even with large numbers of markers, information for estimating admixture proportions of individuals or groups is limited and estimates typically will have wide confidence intervals (13).

The alleged relationship between the cross-sectional shape of the hair shaft and the form of the hair, e.g., curly or straight hair, is less than dogmatic. Three-dimensional computer-aided reconstructions have documented that the follicle form determines the appearance of the hair, e.g., the "African" follicle has a helical form, whereas that of the Asian follicle is completely straight. The IE follicle represents variations between these extremes. However, even a straight IE follicle may produce a hair shaft that has an oval cross (14).

Few biological data on curly hair follicles have been reported in the literature. However, follicles dissected from scalp skin samples from African, Guyanese, and Caucasian volunteers

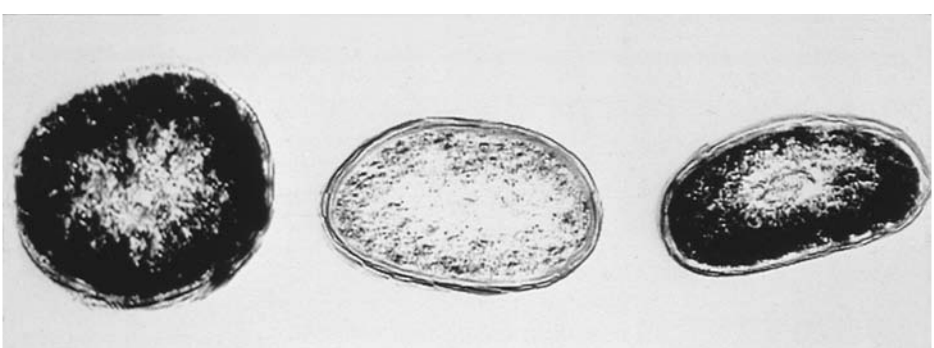

FIGURE 5 Cross section of (*left to right*) Asian, Indo-European, and African hair.

FIGURE 6 EMG of (*left to right*) Asian, Indo-European, and African hair. Note the propensity of African hair to fold (curl).

were observed macroscopically in culture in Williams' E medium, and by immunohistochemistry. Macroscopic study of scalp biopsies obtained from African volunteers showed that the dermal implantation of follicles was curved with a retro-curvature at the level of the bulb, as opposed to a straight shape in Caucasian (IE) follicles. The bulb itself was bent, in the shape of a golf club, while both the outer root sheath (ORS) and the connective tissue sheath were asymmetrical along the follicle (15).

In vitro growth of curly hair follicles was slightly slower than that of Caucasian follicles but, more importantly, the curvature was maintained in the hair shaft produced in vitro. Immunohistochemistry revealed that the proliferative matrix compartment of curly hair follicles was asymmetrical, with Ki-67-labeled cells more numerous on the convex side and extending above the Auber line. On the convex part of the follicle, the ORS was thinner and the differentiation programs of the inner root sheath and hair shaft were delayed. Some ORS cells expressed alpha-smooth muscle actin protein on the concave side of the curvature, reflecting a mechanical stress. The authors concluded that hair curliness is programmed from the bulb and is linked to asymmetry in differentiation programs.

Alternatively, the origin of the curliness of human hair has been reported from studies employing scanning microbeam small angle X-ray scattering (SAXS), based on the nanostructure of keratin fiber arrangement. Scanning microbeam SAXS patterns of single hair fibers have been measured across the fibers. The differences in the patterns between the inner and the outer sides of the curvature were successfully detected (16). The analysis of the equatorial and azimuthal scattering intensity profiles showed that the arrangement of the intermediate filaments was different between the inner and the outer sides of the curvature. From the analogy with Merino and Romny wool, it is suggested that different types of cortices exist in human hair. It is concluded that, regardless of the ethnic origins, the macroscopic curl shape of the hair fiber originates from the nonhomogeneity of the internal nanostructure, arising from unhomogeneous distribution of two types of cortices.

Adaptive Changes in Hair Morphology

Since Africa is the home of humankind, it is appropriate to commence here with a discussion of hair morphology. "African" phenotypes show as much diversity as do their genotypes. The classical hair of equatorial Africa is also seen in equatorial regions of Indonesia and Australia. This type of hair is tightly coiled, with a thick appearance and feel. Curiously, some Indo-Europeans also express this phenotype (Fig. 7).

Many of the populations of northeastern Africa have looser, less tightly coiled hair than most other Africans. Andamanese peoples, the Negrito, are phenotypically African but are in fact a recent Asian branch. Their small stature, heavily pigmented skin, and tightly coiled hair represent a recent adaptation to equatorial existence. Melanesian peoples express the same traits. Late African phenotypes are thinly spread throughout the world. Indigenous Australian peoples exhibit the same phenotype and some Aboriginal infants are born with blonde hair.

Wooly hair syndrome is a condition affecting a small percentage of persons of IE and Asian heritage. It is characterized by extremely frizzy and wiry hair that looks almost wooly in appearance. Wooly hair is a rare defect in the structure of scalp hair. This hair is either present at birth or appears during the first months of life. The curls, with an average diameter of 0.5 centimeter, lie closely together and usually make the hair difficult to comb. In addition, the hair may be more fragile than usual. The syndrome usually lessens in adulthood, when wavy hair often takes the place of wooly hair.

FIGURE 7 A northwestern European child with tightly curled hair.

The difference between wooly hair in Africans and the hair found in non-Africans with the syndrome is that African hair lies typically separate and is tightly coiled or spiraled, while the curls of the latter tend to merge. This type of hair often only covers portions of the scalp.

Weathering

Weathering is the progressive degeneration from the root to the tip of the hair of the cuticle and then later the cortex due to routine everyday wear and tear. Although all hair exhibits some degree of weathering, longer hair, subjected to repeated insults, inevitably shows more severe changes of weathering (Fig. 8). Features of weathering include damaged cuticles, longitudinal fissures known as split ends, and transverse fissures resembling the nodes seen in trichorrhexis nodosa (1).

Function of Human Hair

The function of human hair is, curiously, unresolved. Hypotheses vary: Is it a relic of the hypothetical aquatic phase of human development where a pelage would be an impairment? Is hair an integral adaptation for thermoregulation and ultraviolet protection, a mere adornment, or the result of Fisherian runaway sexual selection? All these theories can be disproved not least by the tendency for humans of both sexes to bald.

Hair may and often is interpreted as a marker of age, healthy nutrition, and fecundity. In its styled form it is employed in all societies to express social status or cultural affiliation. Hair in most cultures is at its zenith on the wedding day as a mark of health, wealth, and sexual attraction. By contrast, sociological studies have revealed the full impact of so-called bad hair days, where subjective and objective negative assessment of hair may reduce self-esteem.

FIGURE 8 Severe weathering.

HUMAN HAIR AND ATTRACTIVENESS

Although hair is cited as a factor contributing to human attractiveness, it is seldom described in terms more explicit than "healthy." From an attractiveness standpoint, a person's face would not have been easily visible across the open grassland, plain, or tundra for early humans or, in subsequent generations, across a darkened dance floor. The appearance of scalp hair, in conjunction with body form, is the key and immediate component of attraction. Physical attractiveness can have very real effects. A survey of 11,000 people conducted by London Guildhall University revealed that people who were described as physically attractive earned on average 13% more than those who were deemed less attractive (17). This finding, however, might be construed to be the result of the increased self-confidence of people who perceive themselves as more physically attractive. Certain advantages do accrue to such persons: the ability to obtain better jobs, pay, and promotions; more choices in partners and, consequently, more power in relationships; and the opportunity to marry into families with more resources (money) (Fig. 9).

At a distance, or from behind, the quality of a person's hair may imply an age (youth, health, and fecundity) not realized by facial markers (Fig. 10). Conversely, facial beauty may be marred or distracted from by unkempt or unhealthy hair. Of all the parameters by which hair is assessed, shine may be construed as is the most representative of healthy hair and, perhaps by implication, a healthy body (Fig. 11).

Hair, Shine, and Attraction

The face, at close quarters, is the apparent focus of an observer's attention. A considerable body of literature defines and discusses the assessment of facial attractiveness. However, many authors, including Matt Ridley in his acclaimed work *The Red Queen: Sex and the Evolution of Human Nature* (18), discuss the role of hair in attracting a mate.

Hair shine is an optical phenomenon that depends on the parallelism of the incident light, the (micro)roughness of the surface of the body this light strikes, and the translucence of this object. In the case of hair fibers, their morphology, particularly their ellipticity, is of relevance and the interpretation of the photoelectric impulses received by the brain via the eyes is critical. Each hair bears layers of external cells forming the cuticle. Each acts as a mirror that reflects a certain ratio of the incident light, and the higher the number of layers, the higher the ratio of the reflected light and, consequently, the more intense the luster (Fig. 12). Contrast luster is the contrast of the reflected light viewed against an angular dependency. Put in simpler terms, if the source of light, or the observer, moves, the luster changes. Contrast luster may be affected by hair surface damage, hair color, and hair morphology (whether the hair is curly or straight). Other factors that influence contrast luster include the interaction of light with the sawtooth-shaped fine structure of the hair cuticle, or the presence of sebum, which eliminates this fine structure and renders the hair dull and unattractive by an interference mechanism (Fig. 13).

All of these physical factors may subconsciously influence the perception of attractiveness in the eye of the beholder.

Hair Forms, Styles, and Fashions

Until the advent of readily available and reliable cosmetic products, the hairstyle of early *Homo sapiens* must have been somewhat of a gamble. Naturally short hair is an advantage in hot and humid climates and long hair is perhaps more beneficial in cold regions. However, what is ultimately achievable is determined by the phenotype and length of anagen of each hair (Fig. 14).

TABLE 1 Cosmetic Treatments and the Resulting Alteration of Contrast Luster

Factor that influences contrast luster	Effect of product				
	Styling products	Dying (deeper color)	Bleach (lighter color)	Conditioners	Perms
Reflection properties	Increased	Increased	Decreased	Various	Unchanged
Hair set (straight, curled)	Unchanged	Unchanged	Unchanged	Increased	Decreased
Hair damage	Unchanged	Unchanged	Decreased	Unchanged	Decreased
Overall effect	Increased	Increased	Decreased	Various	Decreased