American Academic Scientific Research Journal for Engineering, Technology, and Sciences
ISSN (Print) 2313-4410, ISSN (Online) 2313-4402
https://asrjetsjournal.org/index.php/American_Scientific_Journal/index

Gray Hair and Hair Strengthening: A Professional Guide for Hairdressers and Colorists

Hanna Boiko[a], Dr. Anna Kostevich[b*]

[a]*Sheisart llc, des plaines, il 60016, United States*
[b]*Chicago, IL, Internal Medicine Attending Physician*
[a]*Email: hnnboiko@gmail.com*
[b]*Email: businessusa.start@gmail.com*

Abstract

Gray hair has become an increasingly common concern among clients seeking professional coloring services, not only due to aesthetic considerations but also because of changes in hair strength, density, and fiber quality. As clients' awareness of hair biology grows, professionals are expected to understand the trichological mechanisms underlying depigmentation and structural alterations of gray hair. The purpose of this study is to analyze the biological and structural factors associated with hair depigmentation and to address the problem of maintaining hair fiber quality during coloring procedures. The research problem focuses on the gap between scientific knowledge of gray hair formation and its practical application in professional coloring practice. The study was conducted using a structured analysis of peer-reviewed scientific literature on hair follicle biology, oxidative stress, and melanogenesis, combined with applied professional coloring and care practices. The methodology integrates biological mechanisms of graying with practical diagnostic and cosmetic strategies. The results of the analysis demonstrate that gray hair differs significantly from pigmented hair in terms of follicular activity, oxidative balance, and fiber structure, which directly affects its behavior during coloring procedures. These findings support the need for adapted coloring techniques and targeted care strategies when working with gray hair. This work is significant as it provides an evidence-based framework that helps professionals understand the biological processes behind hair graying, improve coloring outcomes, and support hair fiber strength and quality through informed cosmetic and care decisions.

Keywords: coloring practice; depigmentation; gray hair; hair fiber structure; oxidative stress; professional hair care; trichology.

Received: 11/29/2025
Accepted: 1/29/2026
Published: 2/7/2026

---

* *Corresponding author.*

1.Introduction

Hair graying is a visible consequence of biological changes that occur in the hair follicle during aging and under conditions of physiological stress. Although graying is widely described in the dermatological and trichological literature, in cosmetic practice it is often considered primarily as a problem of pigment loss. In [1] authors demonstrated that hair graying reflects profound metabolic and oxidative changes within the hair follicle, while in [2] emphasized the role of oxidative stress as a central mechanism of follicular aging and depigmentation.

Melanin synthesis depends on the functional activity of follicular melanocytes and enzymatic regulation in the hair bulb [3,4]. Age-related decline in antioxidant defenses leads to the accumulation of hydrogen peroxide and inhibition of tyrosinase, which leads to a progressive decrease or cessation of melanin production [1,2]. Authors in [5] demonstrated that chronic stress induces hyperactivation of sympathetic nerves, leading to rapid depletion of melanocyte stem cells and accelerated hair graying. Earlier histological observations [6] also confirmed selective loss of follicular melanocytes in gray hair.

Gray hair is also characterized by different physical and chemical properties. Unpigmented fibers exhibit increased stiffness, reduced lipid content, altered cuticle organization, and altered porosity, which negatively affect pigment penetration and color stability during cosmetic treatments [7,8]. These features create technical challenges that cannot be solved by conventional color formulations alone.

Despite a growing body of scientific evidence, professional color strategies often fail to take into account the biological and structural specificity of gray hair. This gap between research and practice highlights the need for a comprehensive approach that takes into account follicular biology, hair fiber properties, and scientifically sound cosmetic methods for gray hair.

2.Materials and Methods

This study was conducted as an analytical and applied investigation combining scientific literature analysis with professional coloring practice. Peer-reviewed publications in the fields of trichology, dermatology, cosmetic science, and hair biology were reviewed to examine the mechanisms of hair depigmentation, oxidative stress, and structural changes in gray hair. The selected sources focused on melanogenesis, melanocyte activity, hair follicle aging, and hair fiber properties.

The findings from the literature were systematically analyzed and compared to identify key biological and structural differences between pigmented and gray hair. These factors were then evaluated in relation to their influence on coloring performance, pigment retention, and hair fiber quality during cosmetic procedures.

Based on this analysis, professional diagnostic approaches, coloring techniques, and supportive care strategies were examined for their compatibility with the identified characteristics of gray hair. The collected data were synthesized to develop practical, evidence-based recommendations aimed at preserving hair quality and improving coloring outcomes.

3.Results

3.1. Gray Hair: What Happens Inside the Follicle

For a colorist, understanding these mechanisms is essential for developing the correct coloring strategy and care plan. A team of researchers in [3,4] mapped the mechanism of depigmentation.

3.1.1Loss of Melanin

Hair color is determined by the presence of pigments:

- **Eumelanin** — responsible for dark shades
- **Pheomelanin** — creates red and warm tones

Gray hair appears when the hair follicle stops producing melanin, either completely or partially.

3.1.2 Why Melanin Disappears

Modern research has shown that hydrogen peroxide accumulates inside the follicle, blocking the activity of tyrosinase, an enzyme required for melanin synthesis. At the same time, the activity of catalase, the enzyme responsible for breaking down hydrogen peroxide, decreases. Similar conclusions regarding oxidative stress–driven depigmentation were reported by authors in [5].

As a result, pigment production simply stops.

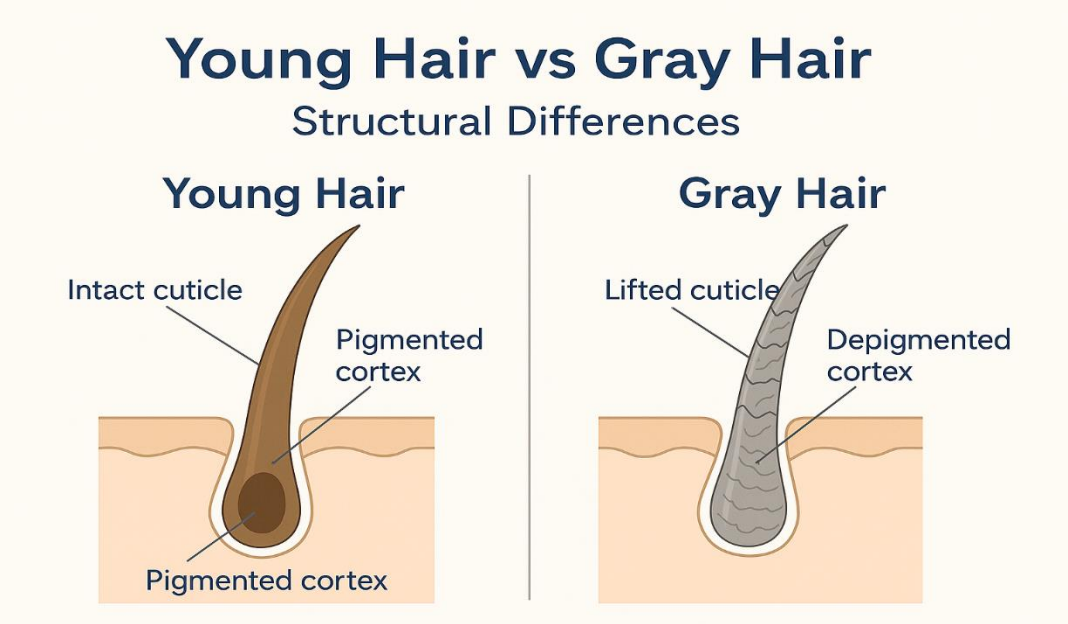

Figure 1: Structural Differences of Young and Gray Hair

3.2. Causes of Premature Graying and Hair Weakening

What a professional should know:

1. Genetics
2. Chronic stress (proven to deplete melanocyte stem cells completely)
3. Deficiency of B12, copper, iron, folates
4. Hormonal imbalance (thyroid disorders, menopause)
5. Oxidative stress
6. Smoking (accelerates graying up to 4 times)

How to explain this to a client in simple, accessible language: "Gray hair is not only about age. Much more often, it is the result of accumulated stress and biochemical changes inside the hair follicle."

3.3. Characteristics of Gray Hair that are Important for Colorists

Gray hair behaves differently—and this must be taken into account when coloring.

3.3.1. Coarseness and Density

Gray hair becomes more rigid and "glassy" due to a reduction in the lipid layer and structural changes in the cuticle.

3.3.2. Porosity

In [8] authors reported that reduced lipid content and increased dryness in gray hair contribute to altered porosity and impaired pigment retention. These structural features explain why gray hair is often less receptive to color treatment and requires targeted pretreatment strategies. A detailed description of the properties of gray hair is presented in [7,9].

3.3.3. Uneven Distribution of Gray Hair

Many clients experience **zonal graying**: temples, parting area, crown.

3.4. Stop-Context: Is it Possible to Restore the Natural Hair Color?

Gray hair is conditionally divided into two types:

3.4.1. Functional Gray Hair (Reversible)

Caused by:

- stress;

- vitamin deficiencies;
- scalp inflammation;
- impaired microcirculation.

This type of graying can be slowed down and partially reversed.

3.4.2 Structural Gray Hair (Irreversible)

- genetic;
- age-related;
- melanocytes are destroyed.

The authors in [5,10] reported that early-stage graying associated with these factors may be slowed down or partially reversed with appropriate interventions.

Structural gray hair, on the other hand, is irreversible and primarily caused by genetic predisposition, age-related follicular changes, or complete loss of melanocytes. The authors in [5,6] emphasized that this type of graying cannot be reversed. And that's why professional colorists must educate clients about the realistic possibilities and limitations of treatment and care.

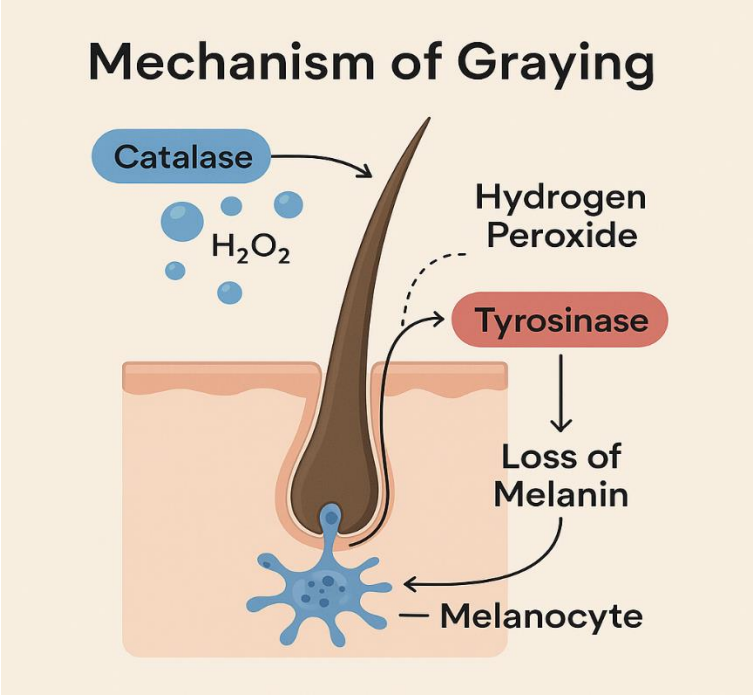

Figure 2: Mechanism of Graying

3.5. What a Colorist can do to Strengthen Hair and Prevent Premature Graying

The role of the professional is **not to treat medical conditions**, but to *support the client professionally*, provide

evidence-based recommendations, and select appropriate procedures and products.

3.5.1. Professional In-Salon Procedures

1. Peptide ampoules and serums

Copper peptides (GHK-Cu) stimulate scalp regeneration and strengthen the hair bulb.

2. Antioxidant protocols

Formulas containing niacinamide, vitamin C, and catalase enzymes.

These reduce oxidative stress, a key factor accelerating gray hair formation.

3. Scalp detox treatments

Including: gentle acid peels, enzyme cleansers, and detox shampoos.

These improve microcirculation and enhance the quality of hair follicles.

Figure 3: Professional Ways to Strengthening Gray Hair

3.5.2. Treatments for density and hair strength

- laminations;
- hair “botox” treatments;

- keratin repair (without harsh formaldehyde-based formulations);
- lipid-layer reconstruction.

These procedures address the rigidity and dryness typical of gray hair.

3.6. Recommendations for At-Home Care

A colorist should explain to the client that **daily care is the key step in strengthening the hair fiber.**

1. Sulfate-free shampoos

Do not overdry or damage the cuticle. The authors in [7,8] emphasized that excessive drying or harsh treatments can damage the hair cuticle and compromise fiber integrity.

2. Scalp serums

Key ingredients include niacinamide, caffeine, peptides, and rosemary extract (clinically studied as an alternative to 2% minoxidil). In [11], researchers highlighted the antioxidant and follicle-supporting potential of plant extracts in hair care products. Clinical observations summarized in [7,8] also indicate that rosemary extract can improve scalp microcirculation and hair quality, making it a promising alternative to pharmacological stimulants such as 2% minoxidil.

3. Oils

Rosemary, black cumin, argan, grapeseed.

4. Antioxidant sprays

Protect the hair from UV damage, preventing oxidative stress.

3.7. How to Work with Gray Hair in Coloring

3.7.1. Diagnostics

Before coloring, the professional analyzes:

- percentage of gray hair;
- its distribution;
- hair density;
- porosity;
- scalp sensitivity.

3.7.2. Techniques for Coloring Gray Hair

Full 100% coverage

Cream colors with double pigment concentration (NN, 00 series). [9] demonstrates how full 100% coverage with double-strength cream colors provides even pigmentation on thick gray hair.

Gray blending/camouflage

For men and women who prefer a softer, less opaque result.

Soft blending

Creates gentle transitions with no harsh regrowth line.

Pre-pigmentation

Essential for dense, “glassy” gray hair.

Contouring and zonal work

Ideal for uneven or patchy graying patterns.

Results presented in [8,9] also confirm that soft blending creates smooth transitions without a sharp root line, while pre-pigmentation is necessary for thick, "glassy" gray hair to improve color absorption. Contouring and zonal treatments are effective strategies for managing uneven or patchy gray hair.

3.8. Strengthening and Prevention: what a Professional Can Recommend

A colorist can create a personalized care plan that includes:

- Antioxidant balance
- Nourishing treatments
- Thermal protection
- Regular reconstructive procedures
- Scalp massage

And explain clearly to the client: “The strength and color of your hair depend not only on dye formulas. They are the result of systemic care and the overall health of the scalp.” A colorist can create a personalized care plan including antioxidant balance, nourishing treatments, thermal protection, regular reconstructive procedures, and scalp massage. The authors in [11] reported that such interventions help maintain fiber integrity, reduce brittleness, and support overall hair health. As emphasized in [12], daily care and appropriate salon procedures are crucial for preserving both hair strength and color retention.

3.9. The Role of the Colorist: Artist + Hair Health Expert

The modern client expects the professional to understand trichology, care science, diagnostics, and even elements of psychology. A colorist is no longer "just a painter"—they work with the hair as a living structure and help the client:

- slow down hair aging;
- improve fiber structure and density;
- reduce brittleness;
- correctly manage gray hair;
- select an effective, personalized care ritual.

A colorist becomes a true hair expert, explaining that beautiful color begins with healthy hair. The authors in Reference [12,13] highlighted that understanding hair biology, follicular mechanisms, and fiber properties is essential for designing personalized coloring and care strategies. By applying these principles, colorists can slow hair aging, improve fiber structure, reduce brittleness, and manage gray hair effectively [10,11].

4.Discussion

Research findings in [4,13] indicate that gray hair undergoes structural and biochemical changes that significantly impact cosmetic treatments. Hydrogen peroxide accumulation, decreased catalase activity, and depletion of melanocyte stem cells contribute to pigment loss and altered follicular function. Furthermore, [9] presents the idea that increased stiffness, decreased lipid content, and altered fiber porosity in gray hair limit color absorption and retention.

These characteristics highlight the need for professional interventions tailored specially to gray hair. Strategies such as pre-pigmentation, antioxidant treatments, and scin-supporting procedures can improve color uniformity and fiber resilience. Integrating scientific knowledge of hair biology into salon practice allows professionals to design individualized care plans, enhancing both aesthetic outcomes and hair health.

The discussion underscores a gap between biological understanding and practical application. Addressing this gap ensures that gray hair is managed as a biologically distinct material rather than merely a cosmetic challenge.

5.Conclusion

Gray hair exhibits unique biological and structural characteristics that influence its response to coloring and care. Evidence-based strategies, including antioxidant protocols, pre-pigmentation, and scalp-supporting treatments, are essential for preserving hair strength and enhancing color retention.

Drawing on both scientific literature and years of professional experience, the author has developed a proprietary methodology for coloring and caring for gray hair. This approach combines biological understanding with practical techniques and is expected to be valuable for other specialists in hair care and coloring.

By integrating scientific insights with applied practice, professionals can provide personalized care, achieving aesthetic goals while maintaining hair health. These findings offer a concise, evidence-based framework for the effective caring of gray hair in salon and home settings.

References

[1] J. M. Wood, et al. "Human hair graying is linked to massive oxidative stress". *The FASEB Journal*, vol. 23, issue 7, Jul. 2009, pp. 2065–2075.

[2] R. Paus & G. Cotsarelis. "The biology of hair follicles." *New England Journal of Medicine*, vol. 341, issue 7, 1999, pp. 491–497.

[3] R. M. Trüeb. "Oxidative stress in ageing of hair." *International Journal of Trichology*, vol. 1, issue 1, Jan–Jun, 2009, pp. 6-14.

[4] A. Slominski, et al. "Melanin pigmentation in mammalian skin and its hormonal regulation." *Physiological Reviews*, vol. 84, issue 4, Oct. 2004, pp. 1155–1228.

[5] B. Zhang, et al. "Hyperactivation of sympathetic nerves drives depletion of melanocyte stem cells." *Nature*, vol. 577, issue 7792, Jan. 2020, pp. 676-681.

[6] S. Commo, et al. "Human hair greying is linked to a specific depletion of hair follicle melanocytes affecting both the bulb and the outer root sheath." *British Journal of Dermatology*, vol.150, issue 3, Mar. 2004, pp. 435–443.

[7] Z. D. Draelos. *Cosmetic Dermatology: Products and Procedures*. Hoboken, NJ, USA: Wiley-Blackwell, 2015.

[8] M. Lodén, H. Maibach. *Treatment of Dry Skin Syndrome: The Art and Science of Moisturizers*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2012.

[9] Kaplan, et al. "Grey hair: clinical investigation into changes in hair fibres with loss of pigmentation in a photoprotected population." *International Journal of Cosmetic Science*, vol. 33, issue 2, 2011, pp. 171-182.

[10] EMJ. Peters, et al. "Graying of the human hair follicle." *Journal of Cosmetic Science*, vol. 62, issue 2, 2011, pp. 121-125.

[11] A. J. Grosvenor, et al. "The Physical and Chemical Disruption of Human Hair After Bleaching – Studies by Transmission Electron Microscopy and Redox Proteomics." *International Journal of Cosmetic Science*. vol. 40, issue 6, Nov. 2018, pp. 536–548.

[12] U. Blume-Peytavi, A. Tosti. *Hair Growth and Disorders*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2008, pp. 253-450.

[13] I. S. Haslam, et al. "Oxidative Damage Control in a Human (Mini-) Organ: Nrf2 Activation Protects against Oxidative Stress-Induced Hair Growth Inhibition." *Journal of Investigative Dermatology*. vol. 37, issue 2, Feb. 2017, pp. 295-304.

[14] M. Brenner & V. J. Hearing. "The protective role of melanin against UV damage in human skin." *Photochemistry and Photobiology*. vol. 84, issue 3, 2008, pp. 539–549.