

**P&G** Oral Care Science

**3-D WHITENING:**  
*The Science Behind a White,  
Bright and Beautiful Smile*

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A person's smile is their first point of communication, so you want that smile to sparkle.

## Beauty and Attractiveness

Dull and yellow teeth can instantly send the wrong message. More and more people are seeking to improve their smile, leading tooth whitening to become the No.1 dental cosmetic procedure.

Overall esthetics and beauty perception are important issues in modern society, affecting social attitudes, interactions and professional advancement.<sup>1</sup> Facial attractiveness is said to play a role in achieving successful mating, kinship opportunities, personality evaluations and performance and employment prospects.<sup>2</sup> During social interactions, one's attention is mainly focused on a speaker's eyes and mouth<sup>3</sup>, establishing a strong connection between smile attractiveness and perceived facial beauty. Research has shown that the aesthetic appearance of teeth has an immediate effect on the way people form an opinion of another person based on a first impression.<sup>4</sup>

In a recent survey conducted by the American Dental Association (ADA), Crest® and Oral-B®, 87 percent of respondents said they feel better after receiving a smile, even when the smile comes from a stranger.<sup>5</sup> Since a smile can say so much, consumers now expect oral care products to deliver not only health benefits but a perfect smile as well.<sup>6,7</sup> In addition to the shape of the teeth, one of the key aesthetic parameters in a smile is tooth color.<sup>8,9</sup> White teeth are considered attractive, and teeth whitening has become the most requested cosmetic dental procedure.<sup>6</sup>

Variable	Percentage Who Scored Higher
Overall Appearance	52%
Interested in Continuing Interview	54%
Confident	61%
Likely to Hire	58%
Attractive Smile	53%
Professional	65%

*Percentage of participants that received higher assessments after whitening their teeth*

In a 2007 study conducted by Loyola Marymount University in Los Angeles, independent, accredited human resource professionals assessed research subjects before and after using an at-home teeth whitener. After their teeth were whitened, participants were viewed to be more attractive and professional, have higher confidence levels and more likely to be hired. They even received longer interviews and larger salary offers.<sup>10</sup> This study shows that having a white, bright smile can help people stand out from the crowd, make a better impression and capitalize on more opportunities.

## Biology of Tooth Color and Tooth Stains

To understand the dynamics of tooth color, one must start with two interrelated concepts: the biological mechanism that leads to tooth discoloration and stain formation.

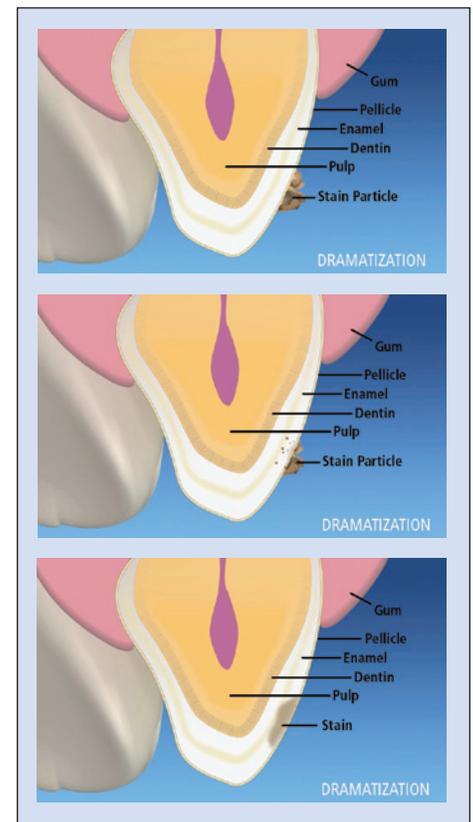
Tooth color is the inherent color of the tooth as perceived by others. It is determined by the transparency of the enamel, the color tone of the underlying dentin and any imbedded staining contained between the dentin and the enamel surface.<sup>8,11</sup> It is also associated with the light scattering and absorption properties of the enamel and dentin. Enamel is a quasi-translucent structure which allows the underlying yellowish dentin color to show through.<sup>11</sup>

**Stain formation:** Researchers have identified many factors that can lead to tooth discoloration and staining, such as bad oral hygiene, dietary considerations (tannins), tobacco usage (tar), medical history and aging.<sup>12,13</sup>

Tooth stain formation can be classified based on the stains location relative to the enamel:

**Extrinsic stains** are located in the tooth pellicle, the tenacious organic film made up of proteins commonly found in saliva that covers the enamel. Pellicle can become stained as a result of daily food consumption and the chromogens, or pigments, contained in food, tobacco and beverages. This film can be cleaned away through dental cleaning and chemical treatments, such as brushing with whitening toothpaste.

**Intrinsic stains** are located beneath the enamel surface. Overtime, chromagenic materials diffuse into the enamel and accumulate at the dentin level and within the enamel. Aging is the primary cause of intrinsic stains. Other possible causes include taking certain medications and eating and drinking foods and beverages that stain over a long period of time. Generally, the only way to eliminate these stains is by bleaching techniques or using professional or at-home whitening procedures.



*Stain particles from food, drink and/or tobacco build-up on tooth enamel. Some stain particles stay trapped in the outer layer of the tooth, while over time others work their way through the enamel. Stain particles that settle beneath the tooth surface make teeth look yellow and dull.*



**Paul A. Sagel**, P&G Research Fellow and inventor of the Crest Whitestrips® technology, was honored with the Society of Chemical Industry Gordon E. Moore Medal in 2007 for his efforts to “produce one of the biggest innovations in home oral care in decades.” With the success of Crest Whitestrips® Classic™, Paul and his team of researchers at P&G Oral Care have continued to build on the brand’s trusted formula to deliver the next generation of superior whitening products.

## How White is White?: Color Measurement

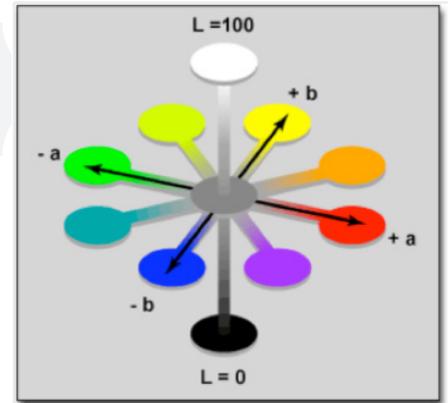
Color is a subjective response of the observer to the physical interaction of the object of view with light.<sup>13</sup> This subjectivity is seen when describing tooth color. Researchers have noted that aesthetic aspects of tooth color are difficult to quantify, making tooth color perception highly prone to individual variation.<sup>8</sup> Disagreement in shade matching the same tooth has been widely observed, both between professionals and when the same professional is grading the color of the same tooth at different occasions.<sup>14</sup>

As it is particularly important to scientifically track the success of new technologies that whiten teeth, a large body of research has been conducted to objectively measure the color of the tooth.<sup>15</sup>

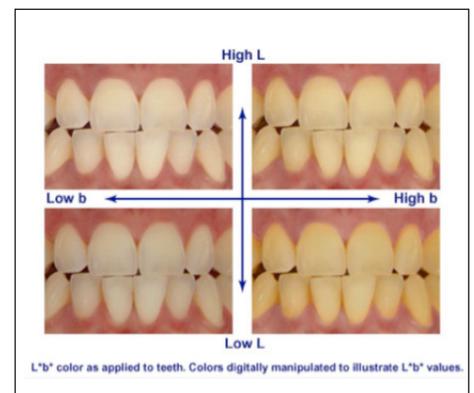
While a variety of scales and measurement techniques have been used to assess tooth color,<sup>8,15</sup> some may be subjective and non-linear, making progress tracking difficult. A common method of measuring tooth color utilizes shade guides, such as the Vita Shade Guide<sup>16</sup> in which the tooth and the guide are observed simultaneously. The results of using this guide depend on several factors, including the observer's experience, external light and the observer's physiological condition.

A more successful mechanism of measuring color was developed by the Commission Internationale de l'Eclairage (CIE), which defined a color space CIE Lab using the accepted theory of color perception based on three separate color receptors: blue (L), red (a), and green (b).<sup>15</sup> With this system, color differences can be objectively expressed in units that can be related to both visual perception and clinical significance.<sup>17</sup>

This methodology has been successfully applied to determine the efficacy of whitening systems by transforming digital high-resolution images of anterior dentition of the teeth taken with standard polarized lighting conditions into numerical values. The whitening benefit is defined as a decrease in b (decrease in yellowness), decrease in a (decrease in redness) and increase in L (increase in lightness).<sup>17</sup>



*L\*a\*b\* Color Model*



## How Tooth Whitening Works

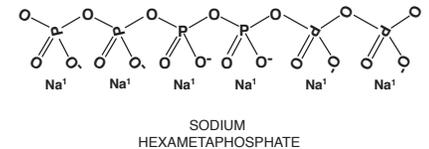
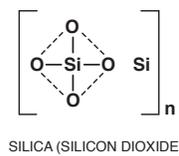
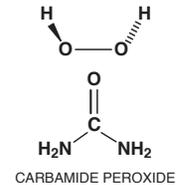
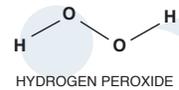
Desired tooth whitening occurs by two means, by either acting upon extrinsic or intrinsic tooth stains and/or preventing the generation of new stains. These outcomes are achieved via: 1) stain removal (brush, paste), 2) stain bleaching (strip, rinse) and 3) stain protection (paste, rinse).

Stain removal whitens teeth by using chemical and physical actions, such as abrasion (silica), chemical stain disruption (SHMP) and removal (brushing, scraping). These different actions either destroy or disrupt the stain at the top of the enamel, exposing cleaner, whiter enamel. Several whitening products base their benefits on these types of actions. For example:

- Whitening pastes contain special silica molecules that polish the enamel.
- Whitening pastes and rinses can also contain sodium hexametaphosphate (SHMP) that helps prevent the formation of future stains and disrupts the stain pellicle, facilitating its removal.
- Toothbrushes remove extrinsic stains by the mechanical action of the bristles on the tooth surface.

- Floss removes plaque and food residues between teeth, thus helping to disrupt the staining pellicle.
- Scrapers remove extrinsic stains by mechanically destroying the stain pellicle. (While the above mentioned products are available to the general public, scrapers are limited for professional use.)

To remove stubborn intrinsic stains that accumulate below the enamel surface, bleaching is an appropriate option. Bleaching is a chemical process in which color is eliminated by oxidation of stain molecules. The bleaching power of the different whitening products varies according to their particular concentration of hydrogen peroxide.



TYPICAL TOOTH WHITENING INGREDIENTS	
Ingredient/Compound	Mechanism of Action
<b>Hydrogen Peroxide (H<sub>2</sub>O<sub>2</sub>)</b> —A bleaching agent, commonly used in whitening procedures at the dental office and in-home kits.	Although the mechanism of the bleaching process is not completely understood, it is generally believed that tooth whitening is the result of oxidation of unsaturated (colored) extrinsically or intrinsically derived stains or non-functional components in or on the enamel and dentin. In some instances, the bleaching action of the hydrogen peroxide is enhanced by the used of blue light, though the real benefit of the use of light is still under investigation.
<b>Carbamide Peroxide (CH<sub>6</sub>N<sub>2</sub>O<sub>3</sub>)</b> —A mixture of urea and hydrogen peroxide that is widely used as a bleaching agent.	In a water-based solution, carbamide peroxide breaks down into hydrogen peroxide and urea, with hydrogen peroxide being the active bleaching agent. Then, the hydrogen peroxide oxidizes stains.
<b>Silica (SiO<sub>2</sub>)</b> —A form of silica dioxide that is commonly used in dentifrices.	The granular particles of different silicas eliminate extrinsic stains due to their ability to reduce the thickness of the colored pellicle through their polishing action while brushing.
<b>Sodium Hexametaphosphate [(NaPO<sub>3</sub>)<sub>6</sub> or SHMP] and Pyrophosphates</b> —A family of phosphates and polyphosphates that are widely used in the food and cosmetic industries.	They work in two ways: (1) by disrupting the extrinsic stains during the action of brushing, therefore facilitating their removal and (2) by adhering to the pellicle and enamel via a thin protective layer, therefore preventing further depositions and accumulations of chromophores.

# Tooth Whitening Product Regulation and Safety

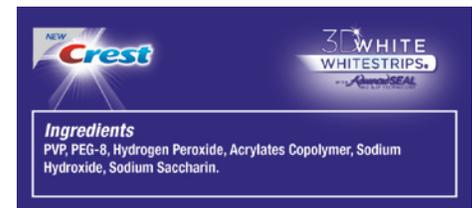
Tooth whiteners are mostly marketed as cosmetic products in the United States. The U.S. Food and Drug Administration (FDA) regulates cosmetic products under two federal laws – the Federal Food, Drug and Cosmetics Act (FDCA) and the Federal Fair Packaging and Labeling Act (FPLA). While the FDA does not mandate a pre-market approval process for cosmetics, manufacturers are responsible for demonstrating the safety and effectiveness of their products before they place them into market. Additionally, it is the manufacturer's and/or distributor's responsibility to ensure that products are labeled properly and comply with all FDA regulations. The regulations require that ingredients are accurately declared on the label. Sometimes reading the labels of cosmetic products can be challenging as ingredients have very long and complex names. The FDA requires the use of consistent nomenclature for ingredient labeling (such as International Nomenclature Cosmetic Ingredient 'INCI names'). This helps drive consistency across product labeling and minimizes confusion that may arise if various synonyms for the same ingredient are used. Additionally, this ensures consumers can make informed purchase decisions regarding the contents of the products.

In some instances, products such as toothpastes provide a whitening benefit through their stain removal capability. Toothpastes are over-the-counter drugs and, as such, are regulated by the FDA under the aforementioned laws. There are specific labeling requirements for drug products, including listing the cosmetic components of the toothpastes in the Inactive Ingredients section of the product's Drug Facts.

Extensive testing has shown whitening products containing peroxide, the same enamel safe ingredient dentists use, are safe when used as directed.<sup>19,18</sup> Manufacturers include clear instructions on how to use the products to ensure the best experience results for users. While some people could experience temporary tooth sensitivity or gum discomfort when using whitening products, this is temporary, and it is not harmful.



*Drug Facts listing for Crest 3D White Vivid toothpaste.*



*Ingredients listing for Crest 3D White Whitestrips® Advance Seal.*

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**3DWHITE** is a collection of Crest and Oral-B tooth whitening products with unique roles that work independently or together (in various combinations) to deliver whitening results that turn heads.



### New Crest 3D White Professional Effects Strips with Advanced Seal Technology

- Delivers professional-level whitening, satisfaction guaranteed
- Includes longer bottom strip for greater coverage, designed to reach more teeth
- Crest's most efficacious concentration of whitening ingredient at retail, including hydrogen peroxide (10%), the same enamel-safe ingredient that dentists use
- Innovative Advanced Seal technology creates a moisture-activated, solid-gel adhesive whitening treatment that provides advanced adhesion to fit every person's unique smile and comes off clean leaving no mess behind



### Crest 3D White Multi-Care Whitening Rinse

- Designed to be worn once a day for 30 minutes
- \$50 per kit, 20 whitening doses
- Triple-action formula uses same whitening ingredient as Crest Whitestrips. Whitens by removing surface stains, helps to prevent new surface stains from forming and freshens breath

### New Crest 3D White Vivid Toothpaste



- Get a whiter smile in 14 days, satisfaction guaranteed

- Removes up to 80% of surface stains in 14 days
- Patented dual-action silica system helps polish away surface stains to gently whiten teeth
- Unique paste-gel hybrid formulation offers the cleaning of a paste and the freshness of a gel, helping teeth feel smooth and clean
- Its lower density formula provides a smoother experience that keeps people brushing
- Contains a special blend of ingredients that deliver and sustain freshness signal after use
- Ingredients include: sodium fluoride, pyrophosphate, dual-action silica, in a paste-gel hybrid formulation



### Oral-B 3D White Vivid Toothbrush or Oral-B 3D White Advanced Vivid Toothbrush

- **Vivid Brush:** Cleans and whitens by removing surface stains
- **Advanced Vivid Brush:** Vibrating bristles polish away surface stains on and between teeth

**The 3D White Collection from Crest & Oral-B**  
Start seeing results in one day

