COLOR GRADING OF COLORED DIAMONDS IN THE GIA GEM TRADE LABORATORY

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The GIA Gem Trade Laboratory (GIA GTL) presents the system it uses to color grade faceted colored diamonds, and the information on which it is based. This system involves a trained grader establishing the characteristic color in a standardized illumination and viewing environment, using various reference materials for color comparison. Here, the Munsell color system is used to illustrate the relationships between the different color terms used. GIA GTL "Fancy grade" nomenclature for colored diamonds has been expanded to better address all colors. This color terminology will soon be incorporated into a new GIA GTL colored diamond report.

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Natural-color colored diamonds, traditionally referred to as "fancy colors," hold a special position in the diamond industry. To recall such historic diamonds as the blue Hope, the Dresden Green, or the pink Agra is to conjure up visions of mystery and intrigue, royalty and revolution. Known to many as the "ultimate gem" (figure 1), fancy-color diamonds often command extremely high prices. Perhaps the most celebrated example is the 0.95-ct round brilliant Hancock diamond, first graded "Fancy purplish red" by the GIA Gem Trade Laboratory (GIA GTL) in 1956 (Kane, 1987; Federman, 1992a). Purchased at that time by a Montana collector for US$13,500, in 1987 it sold at auction for $880,000, a record $926,000 per carat. Seven other fancy-color diamonds were sold at auction in the past few years for prices over $250,000 per carat (see list in Giovannini-Torelli, 1993). And in October 1994, a 20.17-ct blue diamond of unknown provenance sold at Sotheby's New York for $9,902,500, or $490,952 per carat (see figure 2 and the cover of this issue).

Whereas colored diamonds were once infrequently encountered, today we see increasing numbers—and a broader variety of colors—in the marketplace (figure 3). For example, during the last decade the Argyle mine in Western Australia has made significantly more colored diamonds available (Hofer, 1985). Some of these diamonds, such as the intensely colored pinks (figure 4), command high prices ($75,000 or more per carat; Federman, 1989a; Cockle, 1994; Winton, 1994); others, such as the brown stones being sold today under the trade names "champagne" and "cognac," provide an affordable alternative to "white" diamonds (Sielaff, 1992; Wagstaff, 1994).

As colored diamonds increased in availability and value, publicity in the trade press also increased (Federman, 1989a and b, 1990a and b; Shor, 1990, 1991; Stephenson,

Figure 1. Fancy-color diamonds represent some of the most prized objects in recorded history. These diamonds illustrate some of the colors that diamonds may exhibit naturally, as well as different GIA GTL color grades. For example, the marquise-shaped stone in the ring on the left is a 1.86-ct Fancy Deep blue, whereas the 2.14-ct pear shape is a Fancy blue. The center stone in the other ring is a 1.11-ct Fancy Intense yellow-green. The 12.50-ct briolette is Fancy yellow. The 2.15-ct briolette is Fancy Deep pink, while the 4.43-ct cushion-cut stone to its left is Fancy pink. These six stones are courtesy of American Siba Corp., Ishaia Trading Corp., Moses Jewelers, Isaac Wolf, and Lazar Wolf. Photo © GIA and Harold & Erica Van Pelt.

1992; Bronstein, 1994).[1] This has generated even more interest in colored diamonds and awareness of their special value, further stimulating the market.

In addition, as natural-color colored diamonds have become more prevalent and more valuable, more diamonds that have been color altered by laboratory treatment have also entered the trade. Establishing the "origin of color" of a colored diamond (that is, whether it is natural or laboratory treated) is a great concern for many clients of the GIA Gem Trade Laboratory. Addressing this question has been a major ongoing research effort (involving the examination of several thousand colored diamonds) at both GIA Research and GIA GTL (see, e.g., Ashbaugh, 1992; Fritsch and Shigley, 1989, 1991; Fritsch and Scarratt, 1992; figure 5). As a result, every year thousands of colored diamonds are now submitted to GIA GTL for color-origin determination and, if the stone is found to be of natural color, a color grade on the laboratory report.

GIA GTL recognizes that a means to communicate the colors of such diamonds clearly and consistently is vital to effective commerce. In contrast to colorless-to-light yellow diamonds (i.e., those graded on GIA's "D-to-Z" scale), the value of a colored diamond usually depends more on the rarity of its color than on its clarity, cut, or even its carat weight. In fact, in the words of one prominent diamond cutter, "When you're cutting colored diamonds, you throw away the book" (L. Wolf, pers. comm., 1994). Witness the 0.95-ct Hancock "red" diamond that sold for $880,000; although it was not graded for clarity, inclusions were readily visible. No grading system can completely capture the special character of an individual stone, or its effect on the eye of the beholder. Nevertheless, a meaningful

[1] *Other sources of information on the mining, marketing, and lore of colored diamonds are the books by Balfour (1992), Blakely (1977), Bruton (1978), Davies (1984), Federman (1988, 1992b), Krashes (1993), Legrand (1984), Orlov (1977), Sinkankas (1993), and Zucker (1984). Information on recent auctions of colored diamonds can be found in the Christie's and Sotheby's sales results, and in pricing guides such as D. Palmieri's* Diamond Market Monitor.

Figure 2. This 20.17-ct Fancy Deep blue diamond recently set a record for the highest per-carat price ($490,952) for a blue diamond sold at auction. Courtesy of Sam Abram, American Siba Corp. Photo © GIA and Harold & Erica Van Pelt.

color description (or "color grade," as it appears on a laboratory report) is a critical communication tool for dealer and consumer alike.

GIA GTL has provided a color description standard for natural-color diamonds for many years. Since the mid-1950s, when GIA GTL began issuing colored-diamond reports, periodic refinements have been made to respond to significant developments—especially treatments and new sources. The system is based on a side-by-side visual comparison of the diamond to one or more "color comparators," under controlled lighting and viewing conditions.

Prompted by the fact that almost every significant colored diamond sold in recent years has been accompanied by a GIA Gem Trade Laboratory report, this article describes the system used by GIA GTL to achieve consistent color descriptions for faceted colored diamonds. Although there are other grading systems for colored diamonds and other gemstones, they are beyond the scope of this presentation.

This article also introduces an expanded "Fancy grade" terminology. Historically, GIA GTL reports have used a series of Fancy-grade terms to describe attributes of certain natural diamond colors. These include *Faint, Very Light, Light, Fancy Light, Fancy, Fancy Intense,* and *Fancy Dark*. In the past, not all of these terms have been used for all diamond colors. In this article, these terms are defined, and two new Fancy-grade terms (*Fancy Deep* and *Fancy Vivid*) are introduced. In addition, *all Fancy-grade terms will be applicable to all natural-color colored diamonds.* GIA GTL will soon introduce a new laboratory report for colored diamonds, which uses this expanded Fancy-grade terminology and includes other improvements.[2]

HISTORY OF DIAMOND COLOR GRADING AT GIA

Since its inception in the 1930s, GIA has played an active role in developing practical color grading systems for diamonds and, more recently, colored gems (Shipley and Liddicoat, 1941; Manson, 1982); this includes the 1988 introduction of a colored stone grading course in GIA education. In the early 1950s, GIA introduced its students to the "D-to-Z" grading system for faceted, colorless-to-light yellow diamonds (Liddicoat, 1955), which comprise the vast majority of diamonds seen in the trade. These letter designations were chosen at that time to differentiate the GIA grading system from other, more loosely defined trade classifications, which typically began with the letter *A*. In the mid-1950s, the GIA Gem Trade Laboratory issued its first laboratory reports using this "D-to-Z" color grading terminology. Since then, several million GIA GTL grading reports have been issued. "GIA has given the trade an objective nomenclature, a living standard that is verifiable through its grading reports," according to diamantaire Martin Rapaport (pers. comm., 1994). This has led to increased consumer confidence in faceted diamonds accompanied by these reports—and to a greatly expanded diamond market.

Each letter in this grading system designates a range of diamond color appearances. Specifically, it describes the *relative absence of yellow color* (e.g., from "colorless"—D, to "light yellow"—Z) seen in the diamond by a trained grader working in a controlled lighting and viewing environment. To establish a letter grade for a particular stone, the grader

Figure 3. This collection represents the dramatic range of colors in which diamonds occur naturally. Courtesy of Aurora Gems; Photo © Harold & Erica Van Pelt.

[2]Note that this article contains a number of photos of colored diamonds. Because of the inherent difficulties of controlling color in printing (not to mention the instability of inks over time), the color in an illustration may differ from the actual color of the stone.

Figure 4. Since the mid-1980s, when the mining operation at Argyle in Western Australia went into full production, the market has seen an influx of attractive, highly saturated pink diamonds. The Argyle diamonds illustrated here were part of a lot of more than 50 stones that were submitted to GIA GTL on a single occasion. Photo © Harold & Erica Van Pelt.

visually compares the color appearance of this stone to that of one or more "master color-comparison diamonds" (often referred to as "masterstones"). He or she views them side-by-side in the same approximate orientation, and predominantly table-down through the pavilion facets. In this viewing position, the effects of facet reflections are minimized, and the subtle bodycolor is more apparent.

By definition, each GIA GTL masterstone designates the position *with the least color* in a given color-grade range along a scale often perceived as linear. For example, a single color description of "E" represents a range of color between the finest "E" and that which is just better than the "F" master; a stone with less color would be graded "D". The boundaries on this scale were established both to provide a simple description terminology and to reflect visual color distinctions made in a practical way within the jewelry industry. Some concepts of the "D-to-Z" grading system formed the basis for GIA GTL's ensuing work on grading colored diamonds. These include boundaries marked by diamond masterstones, color terms applying to ranges of color appearances, and side-by-side comparisons in a controlled lighting and viewing environment.

The "D-to-Z" system was specifically designed for colorless-to-light yellow diamonds, but it proved readily adaptable to include near-colorless to light brown diamonds as well. As we continued to refine the GIA GTL grading system, modifications were made to accommodate those "brown" (relatively common) and also "gray" (less common) faceted diamonds that could be considered equivalent to grades between "K" and "Z". For brown stones, a letter grade plus word descriptions of *Faint*, *Very Light*, and *Light* brown are used for grade ranges

K–M, N–R, and S–Z, respectively. For gray stones, we apply verbal descriptions only of *Faint*, *Very Light*, and *Light* gray for these same three letter-grade ranges. (Those brown or gray diamonds that appear more colorless than the "K" masterstone continue to receive the appropriate letter grade without further description.)

GIA GTL's interest in the color origin of colored diamonds was initially sparked in early 1953, when staff members were first shown diamonds treated to "yellow" by cyclotron irradiation (see reports on diamond irradiation by Custers, 1954; Crowningshield, 1958; and Schulke, 1962). As news of the availability of cyclotron-treated diamonds spread in the trade, GIA GTL began to receive large numbers of colored diamonds from clients wanting to know whether the color had been altered by laboratory irradiation and annealing. Almost as soon as it was introduced in 1956, GIA GTL's origin-of-color report began a process of systematic standardization in describing colored diamonds.

During GIA GTL's early efforts to describe color in faceted natural-color diamonds, two important differences from the "D-to-Z" grading system quickly became obvious. First, the *presence of color* in the diamond, rather than its *absence*, was the important criterion. Second, color was best assessed with the faceted diamond in a *face-up position*, given the potentially great influence of cutting style on color appearance. Diamond manufacturers (e.g., L. Wolf, pers. comm., 1984), like our staff, recognized that diamonds that appeared to have a similar bodycolor when viewed table-down could look noticeably different when viewed face-up.

The most obvious example of this is in the transition area for yellow diamonds from the "D-to-Z" scale to the grades used for colored diamonds. Some shapes (such as the "radiant") may intensify the face-up color appearance to the extent that a diamond that might have been graded in the W-to-X range table-down would grade onto the colored-diamond scale. GIA GTL policy is to assess a diamond's color face-up when that color is more intense than that of the "Z" masterstone face-up.

The term *Fancy* was first used on GIA GTL laboratory reports to describe those natural-color faceted diamonds that exhibited either *a noticeable color appearance when the diamond was viewed face-up, or a face-up color that was other than yellow or brown.* The laboratory's color grading system was further refined in the late 1960s and early 1970s, when GIA GTL added several master color-comparison diamonds for fancy yellow diamonds to its diamond master sets. These new masterstones were used to judge the *face-up color of yellow diamonds;* like "D-to-Z" masterstones, they provided important terminology boundaries. Their use was initially prompted by confusion in the trade about the term *canary*, which lacked an accepted definition (G. R. Crowningshield, pers. comm., 1994). Subsequently, additional Fancy-grade terms were introduced (such as *Fancy Intense*), some for diamond colors other than yellow (i.e., some blue and some brown diamonds were described as being *Fancy Dark*). In addition, we began to articulate on our reports the relative proportions of different colors seen in a diamond (e.g., *greenish blue* means that the overall color is less green and more blue).

Figure 5. Green diamonds are an important subject of ongoing research at GIA regarding the separation of natural-color from laboratory-treated diamonds. This 4.24-ct natural-color Fancy green diamond is surrounded by a suite of yellow to green rough diamonds. The cut stone is courtesy of American Siba Corp.; the crystals are from Cora Diamond Corp. Photo by Robert Weldon.

Whenever possible, in collaboration with the trade, we established important boundary distinctions and added appropriate master color-comparison diamonds. However, we acknowledged early on the practical problems of finding and purchasing all the masterstones that would be needed to cover the wide range of colors in which diamonds occur naturally (again see figure 3). Also significant was the problem of obtaining more than one stone of a specific color for use at laboratory locations in different cities.

The appearance of diamonds with very subtle colors other than yellow posed an additional challenge to our nomenclature system. Some diamonds were encountered that, at first, did not appear to exhibit any color when observed in the face-up position; however, when compared to diamonds associated with the "D-to-Z" color grading scale, they clearly displayed hues different from the yellows (and browns or grays). Thus, they required some form of color grade outside of that scale. For example, a diamond graded as "Very Light pink" would have a "color" similar to that seen in the near-colorless range for yellow diamonds table-down and it would display a very subtle pink color face-up. This need to discriminate such extremely subtle colors by a practical system separates the color grading of diamonds from other gemstones. The relative values associated with particular colors, like pink, are very different for these two groups of stones.

Although the system appeared to work well and was repeatable—e.g., from one grader or laboratory locality to the next—GIA GTL continually sought ways to control the variables involved, such as the lighting and viewing environment and color-comparison standards.

SOME BASIC CONCEPTS FROM COLOR SCIENCE

Evaluating the color of an object (such as a faceted gem) by visual means requires some appreciation of what is actually involved in both observing and describing color. The following paragraphs briefly discuss some of these issues; for further details, see the standard textbooks on color science by Billmeyer and Saltzman (1981) and Wyszecki and Stiles (1982).

Observing and Comparing the Color of an Object. Whenever a person tries to establish the color of an object, or compare the colors of two objects side-by-side, several factors must be considered. Color science methodology (see ASTM [American Society for Testing and Materials] standard D1729-89 and references cited above) indicates the following:

1. One should use a consistent, standard source of light with known illumination characteristics.
2. The observation should take place in an appropriate surrounding environment that is neutral in its color appearance.
3. A rigorously defined geometry should be used between the light source, the object, and the observer.
4. If the object's color is to be compared to that of another object, the latter should ideally be a standard color reference material.
5. Observations must be made by a person with normal color vision.

Because any of these factors can influence the visual perception of an object's color, they all must be controlled if accurate and consistent results are to be obtained.

These factors are particularly important when observing color in a gem material. Illumination and viewing environment were addressed early in the development of the "D-to-Z" color grading scale. GIA designed (in concert with color researchers at Macbeth Instruments; R. T. Liddicoat, pers. comm., 1994) and marketed the DiamondLite. According to Shipley and Liddicoat (1941), the DiamondLite was intended to provide constant daylight-equivalent illumination from a filtered incandescent light source, with a controlled lighting direction and surrounding environment, for color grading colorless-to-light yellow diamonds. Subsequently, a constant, daylight-equivalent, fluorescent-type light source was adopted for the DiamondLite. The use of a carefully controlled light source and viewing environment for diamond color grading has been extensively taught through GIA's educational programs.

Because of its size and design, the DiamondLite is convenient as well as effective for grading the relative absence of color in faceted "colorless" diamonds held in a fixed, predominantly table-down position. As our understanding of the factors that influence color appearance in colored diamonds expanded, however, we recognized the need for a different viewing box. It required the controlled light source and neutral color environment that made the DiamondLite so effective for "colorless" diamonds, yet it had to be large enough to meet the viewing and positioning requirements for evaluating colored diamonds.

The systematic observation of color in a faceted, transparent object also presents challenges in viewing geometry and color comparison that are not typically encountered in other fields of color science. When looking at a faceted gemstone, one sees a mosaic of color sensations, depending on the stone's orientation and the relative positions of both the light source and the viewer's eye. In addition, the pattern and relative size of these sensations varies from one stone to another. Diamond's high refractive index, typical manufacture for brilliance, and precise cutting all affect the path of light through a stone and, thus, its color appearance. The size and cut also affect the total path length of light travel within the stone and, therefore, the amount of light absorption. Likewise, both factors influence the overall distribution of color sensations seen by

Figure 6. The 407.48-ct Internally Flawless, Fancy brownish yellow "Incomparable" diamond is shown here with satellite stones (1.33–15.66 ct) cut from the same piece of rough. Note the range of colors that result from different sizes and different cutting configurations. When GIA GTL examined the original 890-ct piece of rough prior to cutting, it was noted to be essentially uniform in color appearance. Photo by Tino Hammid; courtesy of Christie's New York.

the eye. For example, a large piece of uniformly colored diamond rough will often yield cut stones that vary in color appearance depending on their size and cut (see figure 6). It is the need to determine, from this mix of sensations, which color best represents that of the entire gemstone that most clearly distinguishes the evaluation of color in a faceted diamond from its evaluation in other objects (such as fabrics, glasses, plastics, etc.), which usually present a more uniform color appearance.

Finally, the ability to perceive color varies among people, even those who are not regarded as color blind. Those involved in evaluating colored diamonds should be aware of the characteristics of their own color vision, which can be determined through standard vision testing.

Describing the Color of an Object. Color is a continuum that can be defined and described in terms of three attributes (see figure 7):

1. *Hue,* the attribute of colors that permits them to be classed as, for example, red, yellow, green, blue, or anything in between
2. *Tone,* the relative impression of lightness to darkness of the color (also known as *lightness* or *value* in color science)
3. *Saturation,* the strength or purity of the color (also known as *chroma* or *intensity* in color science)

Figure 8 illustrates these three attributes three-dimensionally, as they appear when combined.

The range of all visible colors is known as a *color space.* A *color-order system* is a method of ordering and specifying the colors in a color space by means of a set of standards selected and displayed so as to adequately represent the whole set of colors under consideration (Wyszecki and Stiles, 1982, p. 506). A number of different color-order systems have been devised in an attempt to describe the colors that surround us.

When observing the colors of several objects one at a time, it is natural to rely on color memory to help distinguish one from another. However, a person's visual color memory cannot provide the degree of repeatability that is necessary to describe color consistently (Burnham and Clark, 1955; Bartleson, 1960). Therefore, color comparators—that is, objects of established color in a chosen color system that are used as standard references—are critical. The most obvious comparator would be of the same material as the sample, to remove appear-

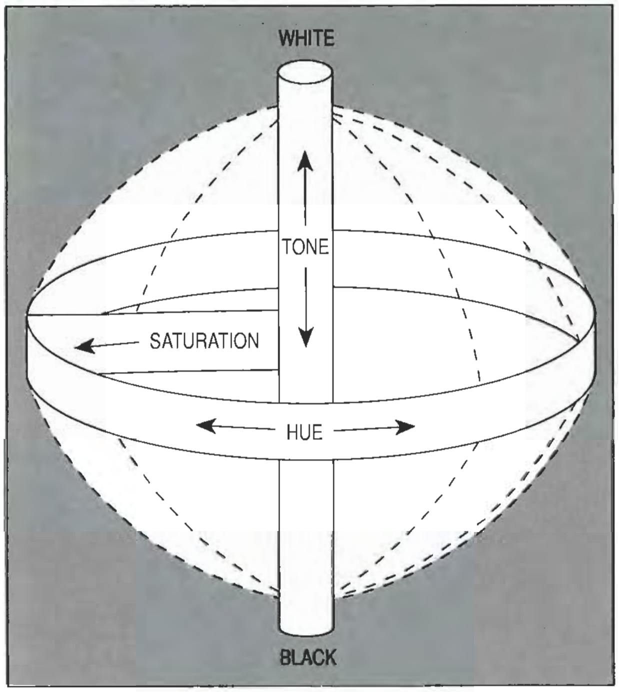


Figure 7. The three attributes of color can be seen here: Hues are located on a circle around a center axis, tone ("lightness" [i.e., toward white] to "darkness" [i.e., toward black]) forms the vertical axis, and saturation forms spokes that radiate outward horizontally from least saturated at the center to most saturated at the rim.

ance variables. As previously noted, however, colored diamonds represent a wide variety of often very subtle colors, some of which are quite rare, and their monetary value may be extremely high. In addition, the color of the stone is influenced by its size and cutting style. Consequently, the cost and time to develop a comprehensive set of diamond color comparators (or masterstones) is challenging. Thus, GIA GTL has investigated other materials that could also function as color comparators.

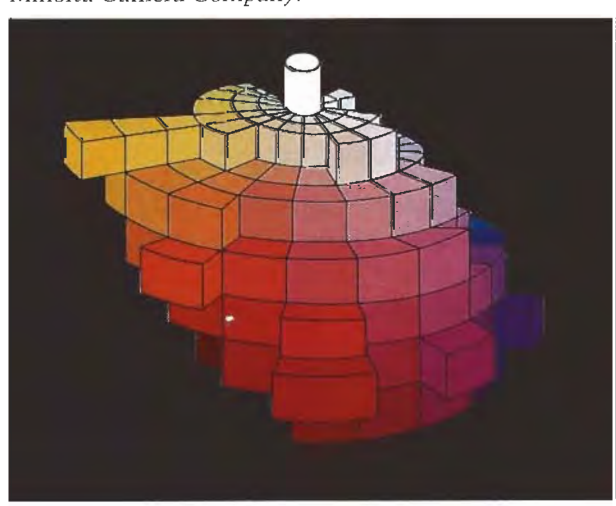
One additional consideration needs to be mentioned. Color descriptions can vary from simple to complex. A rigorous description must involve terms for all the attributes of color—hue, tone, and saturation. The level of detail is referred to as the *fineness* of the description. One of the better-known summaries of the various "levels of fineness" in color terminology is presented by Kelley and Judd (1976). They relate color descriptions to one of six levels of fineness, with each higher level providing for a larger number of color distinctions and having a more complex description terminology (table 1). The needs and level of understanding of the user determine the level of fineness chosen for a color description system. In the case of colored diamonds, a balance must be struck between the need for sufficient detail to describe the color, the need to make the description simple enough to be meaningful to a broad constituency, and the need to describe the color consistently when it is seen in more than one diamond, or in the same diamond on different occasions or in different locations.

THE GIA GTL GRADING SYSTEM

The procedures discussed here for observing and describing color in colored diamonds are primarily based on many years of experience on the part of the GIA GTL staff. In the almost 40 years since the laboratory first began issuing colored diamond reports, staff members have examined and graded tens of thousands of colored diamonds of all colors, sizes, and cutting styles. This cumulative experience has been the most important factor in developing and refining the system described here.

Light Source and Viewing Environment. The current standardized lighting and viewing environment for grading colored diamonds was adopted after the laboratory investigated approximately a dozen possibilities. First, we researched several prototype viewing environments manufactured by GIA GEM Instruments to GIA GTL specifications. We also tested a xenon-type D65 "daylight" light source, which is used as a standard in GIA

Figure 8. Combined, the three attributes of color seen in figure 7 appear as shown here. Note that the saturation steps on the horizontal axis vary with each hue and tone. Illustration courtesy of Minolta Camera Company.



Research. Because GIA is first and foremost a nonprofit educational institution, however, we feel it is important to be able to teach in our training courses what we do in the laboratory. Hence, as our investigation progressed, we recognized that we must use a commercially available viewing box and light source that, if desired, could be purchased by someone in the trade at a reasonable cost. We investigated various alternatives that could be produced by GIA GEM Instruments, but ultimately rejected the concepts of a custom-built viewing environment or the very expensive xenon-type light source. Instead, we turned to products used in other industries, each of which differed slightly in its lighting characteristics. These included viewing boxes manufactured by Macbeth, Pantone, Hunter Labs, and Tailored Lighting (the lighting characteristics of each can be obtained from the respective manufacturers). The viewing boxes we evaluated were reviewed in terms of:

1. The characteristics of its light source—such as lamp type, measured correlated color temperature (a term used to describe the color of a light source) and illuminance (the amount of light energy incident per unit area on a surface, multiplied by the spectral sensitivity of the eye), calculated color rendering index (a measure of the degree to which the perceived colors of objects illuminated by a given light source conform to those of the same objects illuminated by a standard light source) and calculated index of metamerism (a measure of the degree to which pairs of colors with different spectral characteristics appear the same under a standard light source and different under a "test" light source), spectral power distribution, and expected lamp life. These characteristics all contribute to a person's ability to distinguish colors while using the particular light source.
2. The overall illumination level, and evenness of the illumination, within the box.
3. The size and design of the box as it relates to its intended use—that is, grading colored diamonds.
4. The unit cost and ready availability of replacement lamps.

The correlated color temperature of the light sources in these viewing boxes was measured with a Minolta CS-100 Chroma-meter; illuminance level and evenness of light distribution were measured with a Luftron LX-102 light meter. A barium sulfate ($BaSO_4$) plate was used as a white reflectance standard for illuminance-level measurements. In each case, a set of reference colored diamonds were examined in the viewing box by a number of experienced diamond-grading staff members, so project leaders could judge how effectively the color was seen in that viewing environment. Everyone who participated in this experiment was first checked for normal color vision using the Farnsworth-Munsell 100 Hue test.

On the basis of this evaluation, GIA GTL is currently using a viewing box manufactured by the Macbeth Division of Kollmorgen Instruments Corp., and referred to as the "Judge II" (figure 9), for

TABLE 1. The six levels of fineness of the Universal Color Language.[a]

	Level of fineness					
	Color name designations			Numeral and/or letter color designations		
Parameters	Level 1 (least precise)	Level 2	Level 3[b]	Level 4	Level 5	Level 6 (most precise)
Number of color divisions	≈ 13	≈ 30	≈ 270	≈ 1,000–7,000	≈ 100,000	≈ 5,000,000
Type of color description	Generic hue names and neutrals	All hue names and neutrals	All hue names and neutrals with modifiers	Color-order systems	Visually interpolated Munsell notations (from Munsell Book of Color)	Instrumentally interpolated notation
Examples of color description	Blue	Greenish blue	Light greenish blue	Munsell 5B 9/2	4½B 8.3/2.4	

[a]*Adapted from Kelly and Judd (1976).*
[b]*For reporting purposes, GIA GTL uses a level-3 description terminology for colored diamonds.*

Figure 9. The Judge II box provides a standardized viewing environment, with a neutral gray interior color, controlled lighting, and sufficient working distance for making consistent color comparisons of colored diamonds. Photo by R. Weldon.

grading colored diamonds. The box is located in a darkened room to minimize color distractions to the operator. Its interior measures (H × W × D) 20 × 24 × 20 inches (50.8 × 60.9 × 50.8 cm). We have found that the Judge II box offers several specific advantages for observing color in colored diamonds:

1. Its size allows the grader to look at the stone face-up at what, from our experience, is an optimal viewing distance of the stone from both the light source (18 inches, about 45 cm) and the observer (8 to 12 inches, about 20 to 30 cm). At the same time, it provides adequate shielding from extraneous light.
2. The box is deep enough to eliminate color distractions from the surrounding area. We found that graders described the sample colored diamonds most accurately and consistently when they allowed their eyes to color adapt by looking into the box for several minutes and were not subsequently distracted by colors from the surrounding room.
3. The Munsell "N7 neutral gray" interior color reduces color contrasts between the diamonds and the background.
4. One of the light sources available for this box (it comes with several) simulates average daylight with a 6500K color temperature. From our testing, we found that this light source provided superior overall illumination, at a high brightness level, for observing diamond colors at our chosen viewing distance within the box.

Viewing Geometry. As mentioned above, a colored diamond typically has a number of color sensations, and these sensations are often subtle. Therefore, both the position of the diamond in the viewing box, and how the stone is held, are important. We have conducted experiments on various methods of holding the diamond, including the use of tweezers or other metal stone holders and white plastic trays. We have also experimented with holding the diamond in various places within the box to determine where its color is most easily seen. These same considerations apply to the viewing of the color comparators discussed below. Color grading by eye is a subjective process, so decisions on procedural matters such as these were based, after repeated trials, on the recommendations of the grading and technical staff involved.

A faceted diamond's face-up color is evaluated most consistently when the light source is positioned directly above the diamond (figure 10). The stone itself is placed in a grooved, matte-white, plastic tray. (A tray colored gray like the interior of the viewing box tended to make the diamond appear too dark.) Tweezers or other stone holders were all found to potentially influence the diamond's color appearance. In some cases, they add an unwarranted color to that of the stone, especially in paler colors.

Determining the Diamond's Color Grade. GIA GTL uses a three-step process in color grading a colored diamond: (1) determine the face-up color that is to be described; (2) locate the position of that color (first hue, then tone and saturation)—i.e., bracket it—in color space, by visually comparing the stone side-by-side to reference comparators under controlled lighting conditions in the viewing box; and (3) assign GIA GTL color terminology (i.e., the color grade) for that portion of color space.

Characteristic Color. The GIA GTL system describes a single color as being "characteristic" of the diamond as a whole. We define this single color as *the overall color sensation seen when the stone is viewed face-up* (that is not obvious surface reflection, dispersion, windowing ["washed out" or "see through" areas], or extinction ["dark" or "blackish" areas]). To help determine the characteristic color,

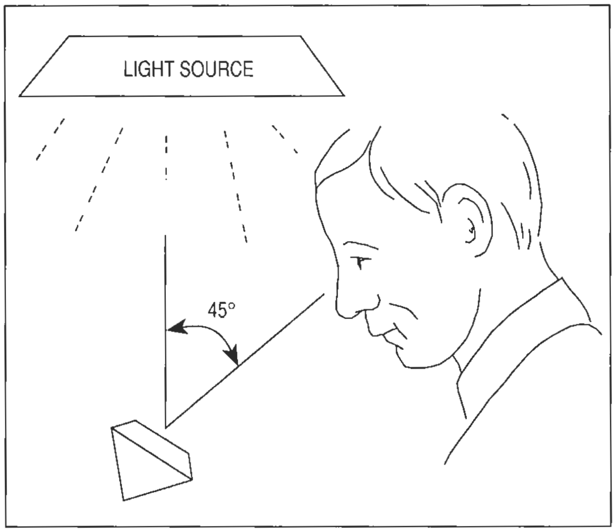


Figure 10. Using a standard viewing geometry such as the one shown here, a trained grader can most readily see and evaluate a faceted diamond's face-up color.

the grader moves the diamond slightly by rocking the tray, so that the stone is viewed from perpendicular to the table facet to perpendicular to the crown facets. In our experience, this process of moving the diamond through a slight angle minimizes the effects of surface reflection, dispersion, windowing, and extinction; for the most part, light enters and returns through the crown facets of the stone (see figure 11).

The "color grade" that a colored diamond receives on a GIA GTL laboratory report is a description of this characteristic color using standardized terms. Figure 12 illustrates various colored diamonds and where the characteristic color is seen in each.

Color Comparators. Once the characteristic color has been determined, it is bracketed in color space by means of a side-by-side comparison with two or more color comparators. As mentioned earlier, it is not always possible to use diamonds themselves as color comparators. However, GIA GTL does use reference colored diamonds for most common diamond colors and, equally important, for significant color distinctions. For example, a substantial distinction that must be made for some blue diamonds is between "Fancy Light" and "Fancy." Therefore, GIA GTL uses a blue diamond at the boundary between these two grades, even though blue is a relatively uncommon diamond color.

Figure 11. The viewing geometry used to grade colored diamonds acknowledges that transparent, high R.I., three-dimensional, faceted gemstones present a range of color sensations, as shown in these two photographs. To determine the characteristic color, the grader rocks the tray through a slight angle, so that the diamond is viewed from several positions. In this particular stone, "windowing" hinders observation of the characteristic color when the table facet is tilted slightly away from the grader (left); rather, the grader sees the color in this stone best when viewing it perpendicular to the table (right). In another diamond, however, the situation might be reversed, or the characteristic color might be most evident with the table at a slightly different angle. Photos by N. DelRe.

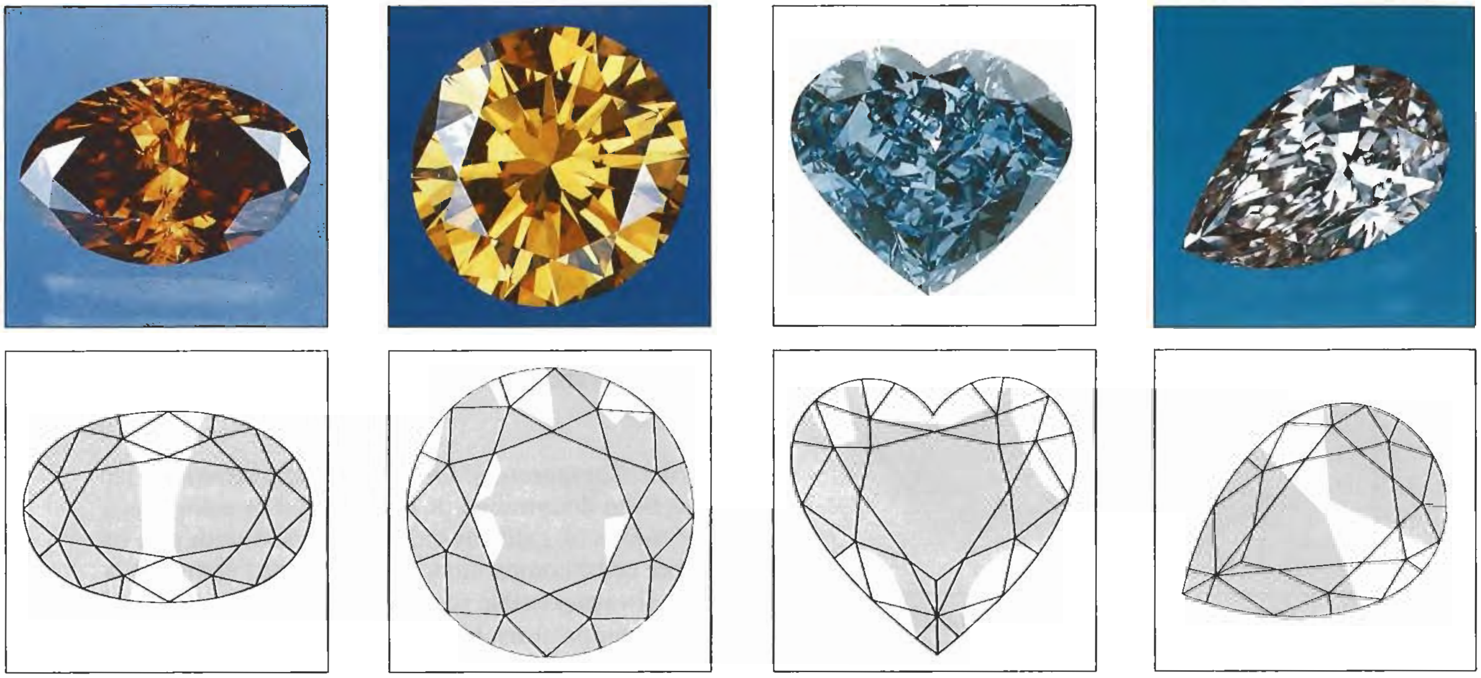


Figure 12. For each of these four fancy-color diamonds, the characteristic color is illustrated by the shaded area on the accompanying drawing. Photos by S. F. McClure and (heart shape) N. DelRe.

To supplement our available collection of colored diamonds and, in particular, to help provide samples for those colors in which diamonds are seen only rarely, we tested comparators from a number of well-known color-order systems. For each system, we considered the commercial availability of the comparators, the number provided and their arrangement in color space, and the range of colors they represented (relative to the colors we know to occur in natural-color diamonds).

We determined that some color-order systems were not compatible for various reasons (for further information on these systems, see Billmeyer and Saltzman, 1981, pp. 25–30; and Wyszecki and Stiles, 1982, pp. 506–507). The first group of systems rejected for our purposes—for example, those of Maerz and Paul, Lovibond, Pantone, and the ICI Color Atlas—are all based on colorant behavior. They employ the principle of systematically mixing various colorants to produce selected color samples (e.g., glasses, plastics, inks, paints, etc.). We found that these comparators are arrayed either too close or too far apart in color space for our purposes.

A second group of systems, represented by that of Ostwald, is based on color-mixing laws; that is, additive mixing of two or more colorants or colored lights in the same proportions yields the same color. Because there is no widely available collection of samples based on this type of system, the comparators in this group, too, were deemed not applicable.

A third group, called "color appearance systems," is derived from the principles of color perception. Here, opaque color chips are used as color comparators, each spaced uniformly in color space in accordance with the perceptions of an observer with normal color vision (Wyszecki and Stiles, 1982, pp. 507–513). This group includes the Munsell Color System, that of the German Institute of Standards (DIN), the Swedish Natural Color System (NCS), Chroma Cosmos 5000, and the Optical Society of America (OSA) Color System. We found that most of these systems were too complex for our specific application. In the course of our investigation, however, we determined that the opaque color chips provided as part of the Munsell system (Munsell, 1905) best suited our needs. This system represents a systematic, three-dimensional, well-distributed sampling of color space (Kuehni, 1983; Billmeyer and Saltzman, 1981, pp. 28–30; Wyszecki and Stiles, 1982, pp. 507–509; Billmeyer, 1987; see also figure 13).

In particular, the distribution of the color comparators in the well-documented and widely used Munsell system along three color attributes (comparable to GIA's terms *hue*, *tone*, and *saturation*) is relatively easy to understand and communicate, which helps its application for our purposes.

Because locations of the opaque chips in color space can be mathematically translated into other color-order systems, they are compatible to systems used in other countries. These opaque chips are a standard color reference for comparison with other objects (ASTM D1535-89) and are sold commercially as the Munsell "Book of Color," which contains as many as 1,500 chips (figure 14).

It is important to note that each Munsell chip *does not* have a descriptive color name. Rather, it carries only its Munsell notation, which positions it in color space (in the Munsell system, on a Munsell hue page). For example, chip 5Y 8/4 is located on page 5Y at a "value" (i.e., tone) of 8 and a "chroma" (i.e., saturation) of 4 (again, see figure 13). We have correlated our color grading system to the arrangement of these Munsell chips, to illustrate how our description terms relate to one another in this color-order system.

Factors in Assigning the Color Grade. When masterstones are used as color comparators, the grader systematically compares the color of the diamond being graded to the colors of the reference diamonds, bracketing each color attribute in the viewing box (figure 15). At this point in the grading process (i.e., after the characteristic color has been established), the diamonds are held in a fixed position. (This is in contrast to the situation mentioned earlier where the subject diamond is moved slightly

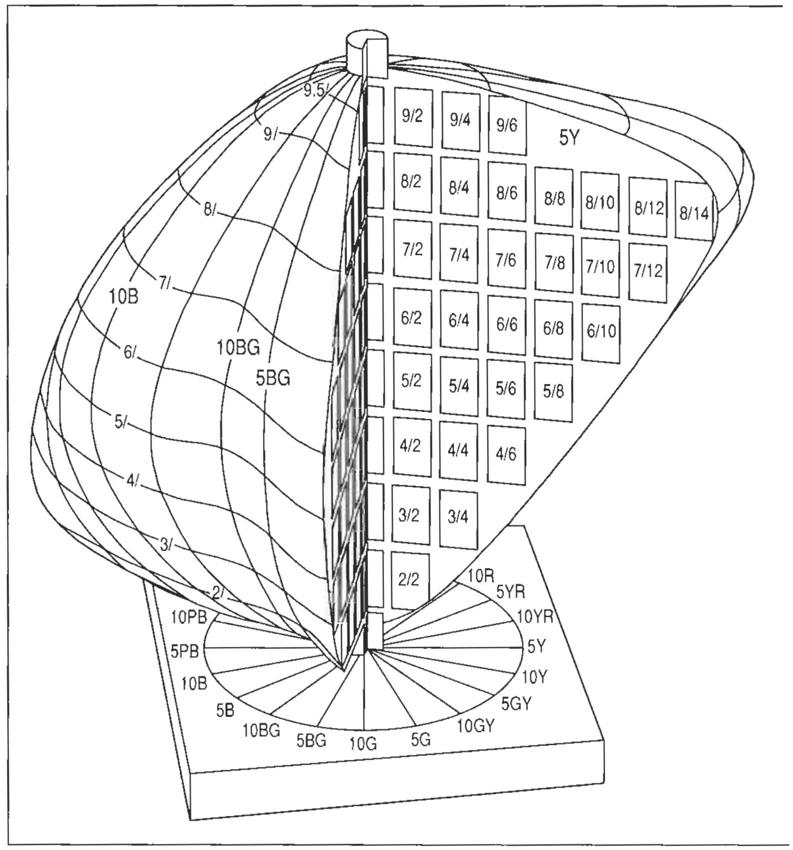
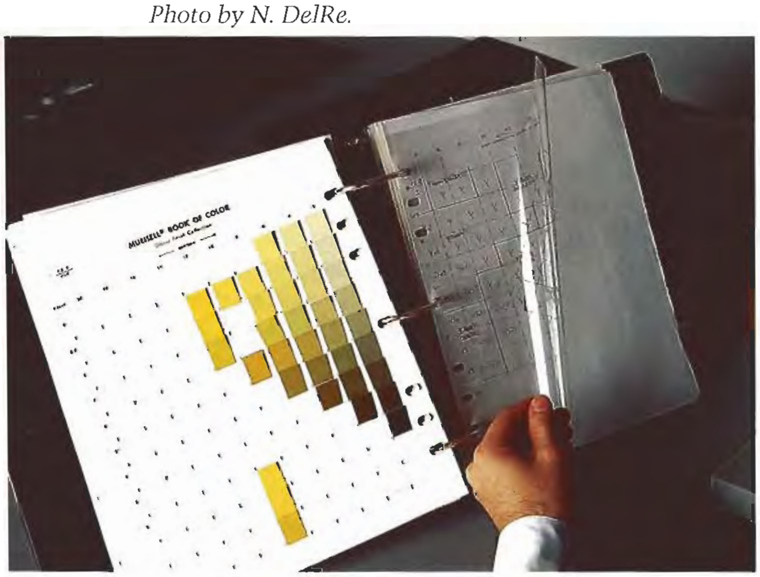


Figure 13. This representation of the Munsell color system shows the arrangement of individual opaque color chips in a color space. Courtesy of the Macbeth Division of Kollmorgen Instruments Corp.

Figure 14. In the Munsell system, opaque color chips are provided in a book, with the chips arranged on what are called Munsell hue pages. Photo by N. DelRe.



to help the grader determine the characteristic color.)

For those less frequent situations where there is not a comparable masterstone, we use the Munsell opaque color chips in much the same way: bracketing by side-by-side comparison of the characteristic color of the diamond with the color of the chip, in the viewing box (see figure 16). ASTM D1535-89 describes the bracketing concept. The grader's goal *is simply to place the characteristic color of the diamond in the proper region of color space*, so the GIA GTL color-description terminology for that portion of color space can be applied to the stone.

An important aspect of the GIA GTL system is the separate analysis of the perceived distribution of color (i.e., evenness or unevenness of color seen face-up). In most cases, unevenness is an effect of the stone's cut; occasionally, the diamond is color zoned. Because this perceived color distribution can affect the diamond's face-up color appearance, it is a

Figure 15. To determine the color description, the grader judges the characteristic color of the diamond against that of color reference diamonds. When comparing the two stones, it is important to place them in the same, fixed viewing geometry and close to each other without touching. Here, a colored diamond (left) is compared to a reference diamond in the viewing box. Photo by S. F. McClure.

factor in how the stone is traded. The grader analyzes color distribution by placing the diamond face-up in a viewing tray and, as with determining the characteristic color, rocking the tray slightly so the stone is viewed from perpendicular to the table to perpendicular to the crown facets. We have found that this rocking motion helps balance the effects of the cut, so the grader is not unduly influenced by the stone's appearance in only one position. The distribution of the color is evaluated in relation to the stone's total face-up area. Most fancy-color diamonds are considered to be evenly colored and are noted as such on the laboratory report (figure 17). In those less-common situations where the characteristic color clearly does not predominate face-up, the color distribution will be called uneven on the report (figure 18).

Figure 16. In some instances, opaque color chips are used as color comparators. As with the reference diamonds, the chips are placed in the same, fixed viewing geometry, close to but not touching the stone. The opaque chip shown here simulates what we consider to be the characteristic color of this diamond. Photo by N. DelRe.

GIA GTL COLOR GRADING TERMINOLOGY

The principles behind GIA GTL's terminology for grading colored diamonds are consistent with those of color nomenclature used in other industries. The Inter-Society Color Council—National Bureau of Standards (ISCC-NBS), when developing their "Method of Designating Colors" (NBS, 1955), used a "level 3" terminology. This level of language was defined by the ISCC-NBS to promote a practical color description terminology *simple* enough to be generally understood by an average person, yet *accurate* enough to be scientifically useful. As shown in table 1, this level includes all hue names (e.g., blue), neutrals (e.g., black, white, and gray), and color modifiers (e.g., light grayish, deep, intense, and other terms that express a related area of tone and saturation values). The GIA GTL system uses a comparable level-3 terminology to describe colored diamonds in terms of hue, tone, and saturation.

GIA GTL is aware that the grader can visually discern more color distinctions than those used in our color grading system. In our experience with colored diamonds, however, a greater degree of "fineness"—i.e., more terms—reduces the consistency and repeatability of the resulting color descriptions. In addition, such color distinctions are only relevant as long as they are meaningful and understandable in the commerce of diamonds; making too subtle or too coarse a distinction is not practical.

Hue Terms. The GIA GTL color-grading system uses 27 hue names (figure 19). *Each name represents a range of color sensations around the hue circle.* In using these hue names, our concern is to mark the boundaries of a given hue—not to designate just a "single" color sensation. We have chosen color comparators to represent the boundaries of each of the 27 hues.

Some of these 27 hue names include a modifying color (e.g., reddish orange); in our grading system, the predominant color is stated last. Note that this hue-naming convention differs from that used in GIA's Colored Stone Grading System (where, for example, green-blue and blue-green are synony-

Figure 17. The color in this 9.05-ct Fancy Vivid yellow diamond is well distributed throughout the face-up appearance of the stone. It would be described as "even" on a GIA GTL report. Courtesy of B. Najjar; photo by R. Weldon.

mous). This is because, in the diamond trade, the final hue name in a stone's color description has significant commercial implications that do not necessarily exist in the colored stone industry (e.g., a green-blue diamond is considered a "blue" stone, while a blue-green diamond is considered a "green" stone, and each has a particular market). These 27 hue names also represent the beginning of what we call our color terminology "grid" for colored diamonds. This grid divides color space into various zones of hue, tone, and saturation; it is helpful in illustrating the relationships among GIA GTL color terms.

Tone/Saturation Terminology. To describe the color of a faceted colored diamond correctly, one must identify its tone and saturation as well as its hue. The Munsell color chips are particularly useful in this regard.

We conducted a series of color-naming experiments for Munsell chips, involving experienced GIA GTL grading staff. We used a special computer program to select approximately 700 chips from the "Book of Color" so that they were at roughly equal distances from one another in color space. Thus, this subset of chips uniformly spanned the portion of color space covered by the Munsell system (which also spanned the range of colors observed in colored diamonds). We then put these chips in a random sequence, and gave them (one at a time) to each of 12 graders very experienced at describing colored diamonds. The experiments were conducted over a period of several days, to prevent eye fatigue on the part of the participants. We asked each grader to look at a single chip in a viewing box under controlled lighting conditions and then to write down a color description of the chip (using GIA GTL terminology) as if it were the characteristic color of a faceted diamond. We used the results of these experiments as one way to relate our color grades to the Munsell system.

Further experiments with the Munsell color chips and over 3,000 colored diamonds, again using trained grading staff and standard color-comparison methodologies (ASTM, 1991, D1729-89), also helped refine the color-comparison process used for grading. Where masterstones are available for color reference, we have located their positions in color space on the terminology grid by means of extensive visual comparison experiments conducted using GIA GTL grading staff. In addition, we have sought advice from members of the diamond trade to ensure the compatibility of our color-grading terminology with current trade usage.

GIA GTL's term for the combined effect of tone and saturation in a colored diamond is referred to as a "Fancy grade." Historically, the laboratory has

Figure 18. The color appearance of this diamond would be described as "uneven" on the GIA GTL laboratory report. Photo by N. DelRe.

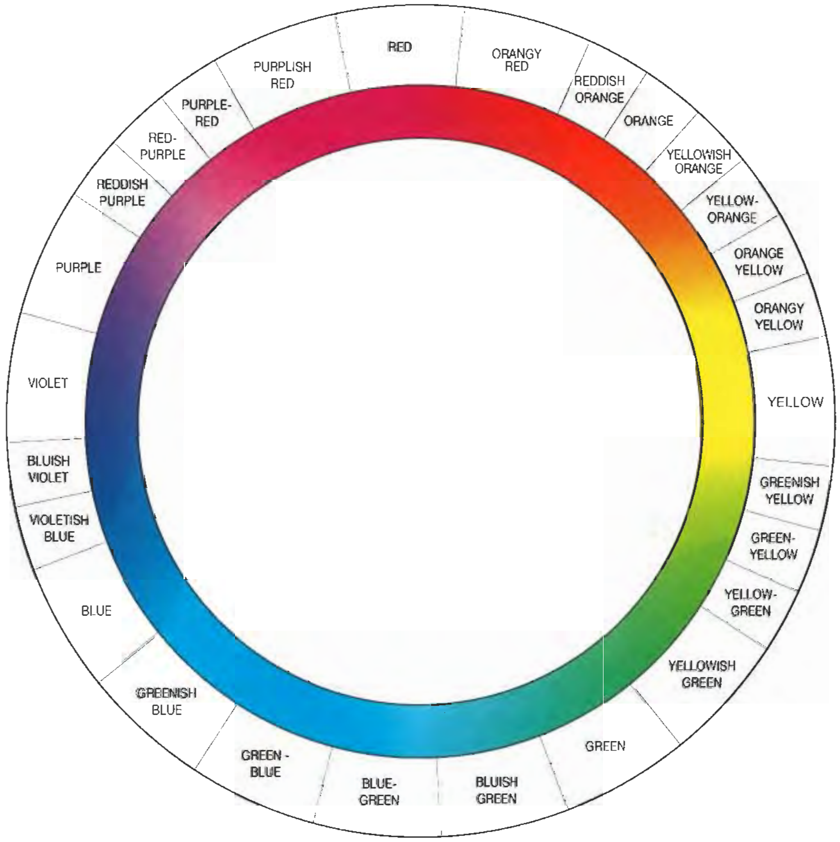


Figure 19. GIA GTL uses 27 hue names on a continuous hue circle to describe colored diamonds. Also shown is the approximate portion of the hue circle to which each name corresponds.

used a series of these Fancy-grade terms on its colored diamond reports; the grade given to an individual stone may have a significant commercial impact. The laboratory's use of these "Fancy" grades is similar to the convention used in the ISCC-NBS system, in which ranges of like tone and saturation values are grouped together and described with the same term (e.g., *light*, *dark*, *strong*, etc.). The Fancy-grade terms used on GIA GTL reports can be depicted by means of our terminology grid (figure 20). According to GIA GTL convention, Fancy-grade terminology is used only to describe the characteristic color in a faceted diamond, and not to describe other aspects of a colored diamond's face-up appearance (such as uneven color distribution).

Using the masterstones, opaque chips, and bracketing process, the grader assigns the characteristic color of the diamond to a "volume" of color space. For illustrative purposes, these volumes can be bounded at the corners by the positions of the Munsell chips (see figure 21). Each volume in the grid is designated by a particular color description (e.g., "Fancy orangy yellow") in our grading system. More than one volume may have the same description.

Using the Terminology Grid. In the grading process, the terminology grid is used as follows. A diamond is first compared to one or more of the colored diamond masterstones. *In most cases, the grader can establish the verbal description of the characteristic color at this stage, which concludes the color grading process.* At a minimum, the grader usually establishes one attribute (hue, tone, or saturation) of the diamond's characteristic color by comparison to these masterstones. If necessary, the grader then uses the opaque chips to refine the location in color space of the remaining attributes. Again, the goal is merely to locate the color between known boundaries—not necessarily to match the diamond's color. By this process, the grader establishes the portion of the terminology grid to which the characteristic color of the diamond belongs, and thus its verbal color description as well.

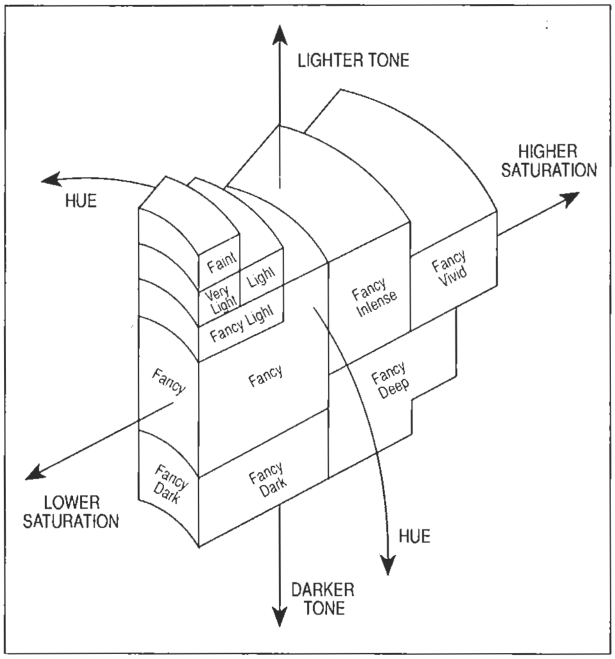


Figure 20. This drawing illustrates the general interrelationship of GIA GTL Fancy-grade terms in color space. The boundaries of these terms shift slightly from one area on the hue circle to another, because not all colored diamonds attain the higher-level saturations. As a result, for some diamonds (such as pink or blue), the GIA GTL grading system gives a paler-colored stone the same Fancy-grade description as a stronger-colored stone with a more common color (such as yellow). Also shown on this illustration are two new Fancy-grade terms, Fancy Deep *and* Fancy Vivid, *and their relationship to the other terms.*

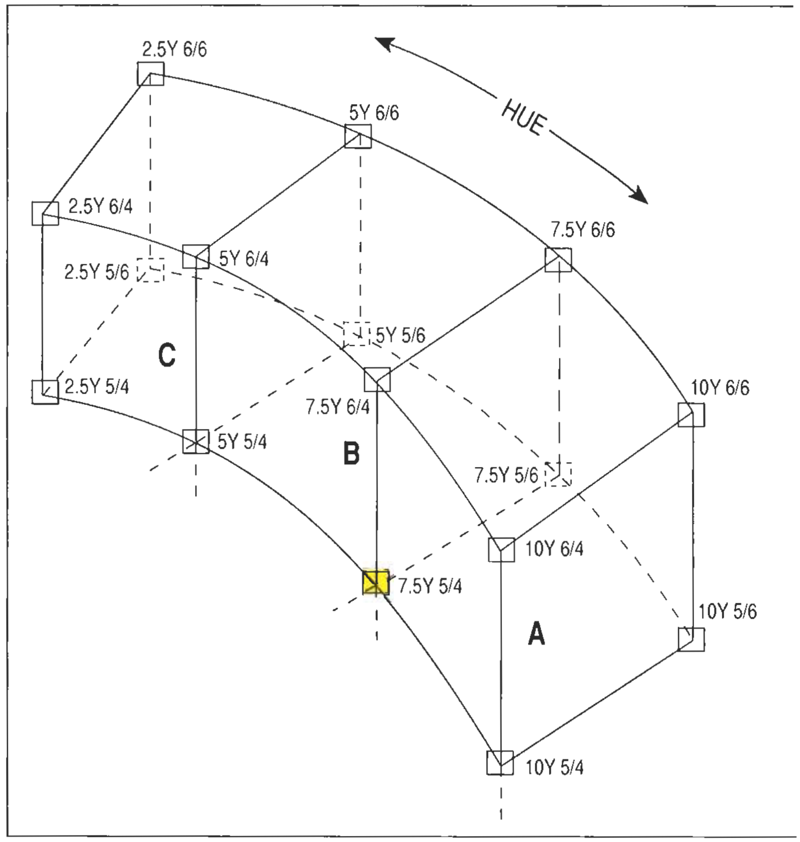


Figure 21. This illustration indicates how a portion of color space can be divided by the arrangement of Munsell chips. Three volumes—labeled here A, B, and C—are shown. By means of the color-comparison and bracketing process, the characteristic color of a faceted diamond can be located within one of these volumes, each of which has been assigned a color grade. In some instances, the grader determines that the characteristic color of the diamond matches that of a particular chip. As the figure shows, however, the chips are actually located at the corners of several different volumes. To prevent any confusion in this situation, the grader uses those terms that represent the highest saturation, lightest tone, and the hue in a clockwise direction around the hue circle. For example, if the match were with chip 7.5Y 5/4—right between A and B—the diamond's color would be described with the terminology that applies to volume A.

With this grid one can visualize GIA GTL's grading terms by looking at two of the three attributes of color at one time. Specifically:

1. Hue and saturation, where tone is kept constant
2. Tone and saturation, where there is a constant hue

These terminology grids help the grader do two things—assign a hue name and assign a "Fancy" grade.

As shown in figures 19 and 20, portions of color space with the same hue and Fancy-grade terms are not all equal in size. The slight differences in the placement of our terminology boundaries are due to the natural occurrence and relative rarity of various diamond colors. Because yellow is by far the most common, a greater depth of this color is required for a stone to receive a "Fancy" grade. In contrast, colors such as pink and blue are both relatively rare and occur in much narrower (lower) saturation ranges. Thus, a "Fancy" grade is given for a paler stone. Such differences in terminology boundaries are illustrated in figure 22.

GIA GTL selected the color descriptions shown on the terminology grids, and the sizes of their respective areas, to provide both (1) a practical limit to the number of terms that would be used based on visual observation, and (2) precise enough terminology to be useful in making commercial distinctions.

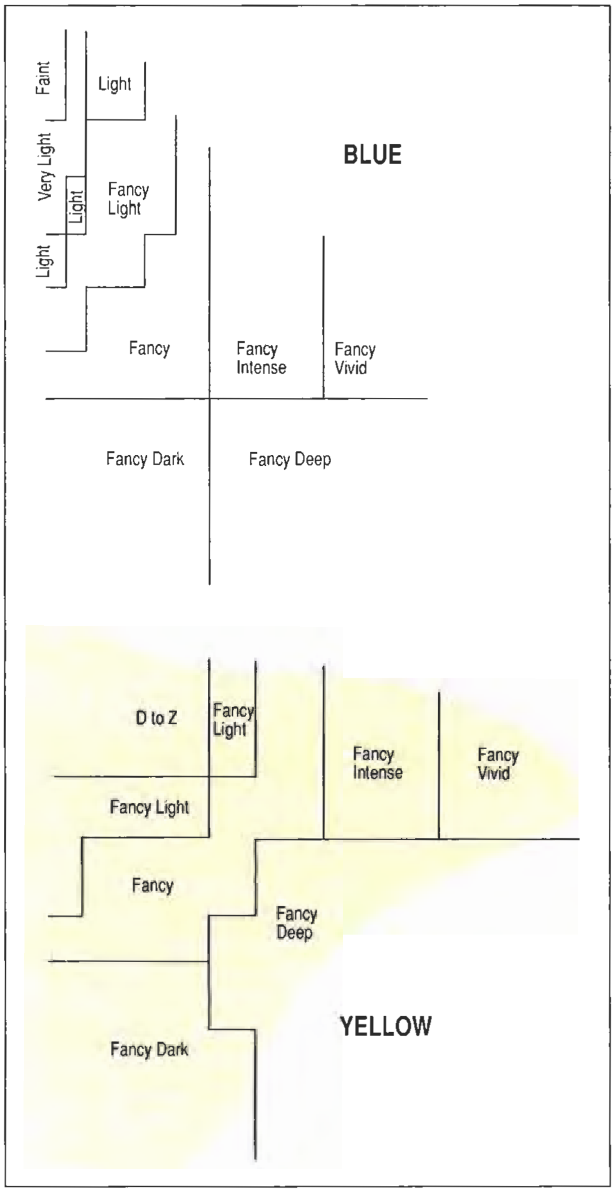


Figure 22. Shown on tone/saturation charts are the Fancy-grade terms for blue and yellow diamonds. Note that the boundaries between terms are different for the two hues. A relatively rare color that typically occurs in lower saturations, such as blue, is assigned certain "Fancy" grades at lower saturation levels than a color such as yellow, which typically occurs in higher saturations. At lower levels, yellow diamonds are graded in the "D-to-Z" range. The shaded areas represent the approximate ranges in which these two colors have been seen to date in diamonds.

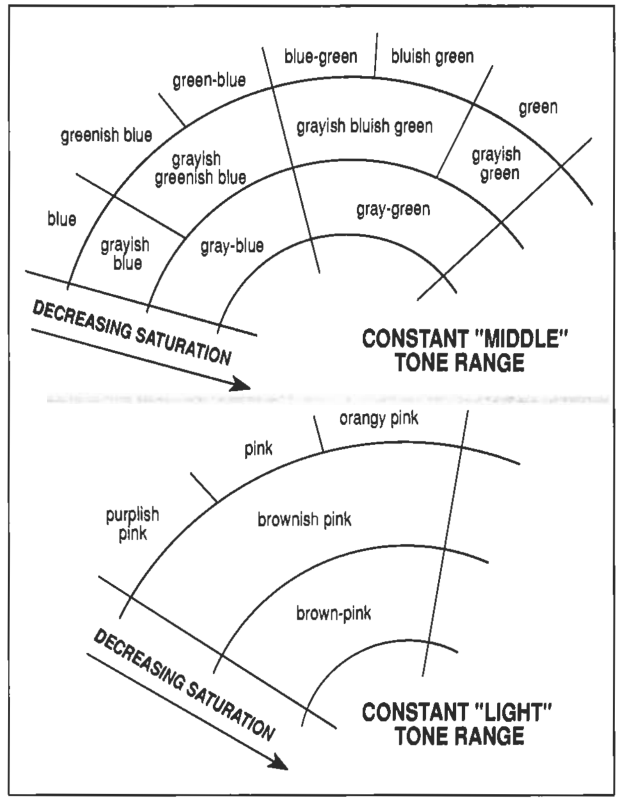


Figure 23. These two hue/saturation grids illustrate the effect that changes in tone and saturation have on the 27 hue names used in the GIA GTL color grading system for colored diamonds. Because the saturation range at very high and very low tone levels is so limited, visual distinctions between these colors become less practical. Consequently, fewer hue names are used in these areas of the two grids. For example, in the bottom illustration, the hue names purplish red, red, and orangy red (shown on the hue circle in figure 19) first become—at this tone and intermediate saturation levels—purplish pink, pink, and orangy pink, respectively. At even lower saturation levels, these three names are combined into just one—first brownish pink, and finally brown-pink. Such a modification in hue terminology is due to the difficulty of discerning the purplish red, red, and orangy red hues at levels of low saturation, and either high or low tone. Similar terminology situations occur throughout the color space used by the GIA GTL colored diamond grading system, as also seen in the top illustration.

Modifications of Hue Terms. There are two kinds of changes that can occur to the 27 hue names, and their boundaries, as one "moves" through the GIA GTL terminology grid. One is a reduction in the number of hue names around the hue circle, and the other is the use of modifying terms as the saturation decreases.

At low saturation levels, and at either light or dark tone levels, we recognize fewer than 27 hue names (figure 23) because there is a smaller number of discernible colors. According to industry sources, this parallels how such diamonds are traded: broader distinctions are made between stones in very dark and very light tones, and at low saturation levels. This is analogous to the convention used in other systems, such as the ISCC-NCS, where fewer

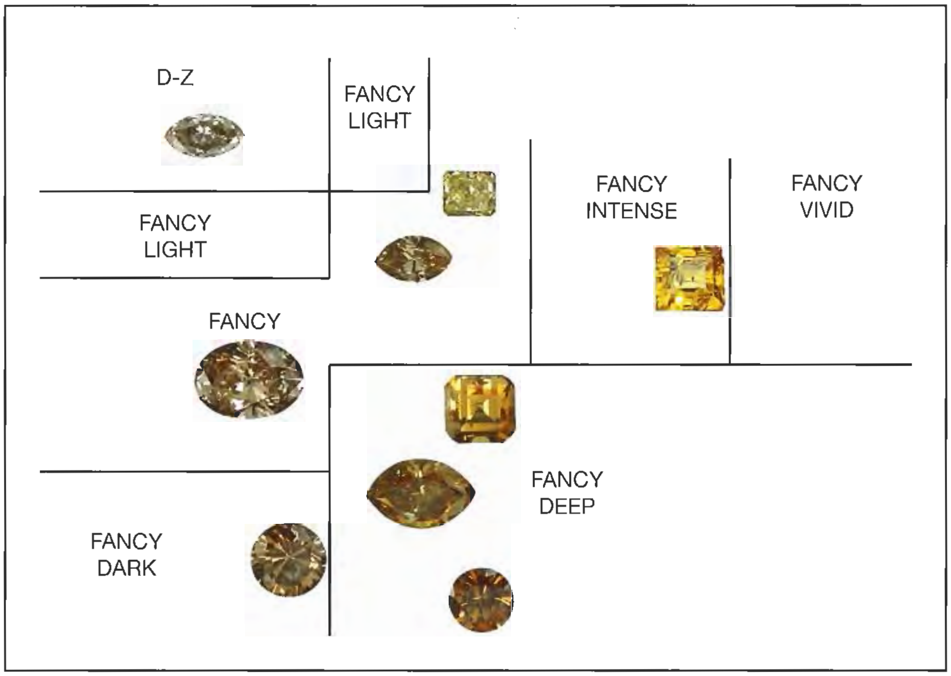


Figure 24. These nine diamonds (0.19–1.06 ct), all in the orange-yellow hue range, are placed on a tone/saturation grid to illustrate the relationship of Fancy-grade terms and color appearance. Note how changes in tone and/or saturation affect the appearance of a hue. Toward the left-hand (lower saturation) side of the grid, brownish *and* brown *are more common in the hue descriptions. Photo © GIA and Harold & Erica Van Pelt.*

hue names are used (i.e., a wider range of colors are grouped together) at lower saturation levels.

When fewer hue names are needed, our 27 hue names are modified in one of two ways. The first is when an English language term is used for paler colors, such as the substitution of "pink" for "red" in the paler versions of "purplish red," "red," and "orangy red" (again, see figure 23). The second way is to modify the hue name by the addition of either "gray/grayish" or "brown/brownish." Some colored diamonds are described in the trade as being brown or, to a lesser extent, gray. In our system, these are not hue terms per se, but they are appropriate color terms to use for the appearance of stones that are at lower saturations of various hues. For example, diamonds in the yellow-to-red hue ranges appear brown when they are particularly low in saturation and/or dark in tone. Most gray diamonds are those that are so low in saturation that no hue is readily perceived, only the light-to-dark tonal changes.

New Fancy-Grade Terminology. One of the recent additions to the GIA GTL colored diamond grading system is the recognition of two new Fancy-grade terms: *Fancy Deep* and *Fancy Vivid.* They supplement the previously existing terminology as follows: *Faint, Very Light, Light, Fancy Light, Fancy, Fancy Dark, Fancy Deep, Fancy Intense,* and *Fancy Vivid* (see, e.g., figures 24 and 25). Referring back to figure 20, *Fancy Deep* represents colors that have a medium to dark tone and a moderate to high saturation (as illustrated in figure 26), while *Fancy Vivid* represents colors that are light to medium tone and very high saturation. With the use of these two new Fancy-grade terms, areas of color space of important, highly colored diamonds will now be given even more accurate and appropriate color descriptions.

OTHER CONSIDERATIONS IN COLOR GRADING

Using Instruments to Measure Color. Certain attributes of color appearance can also be measured with instrumentation, such as a spectrophotometer or a colorimeter (for further general information, see Billmeyer and Saltzman, 1981; chapter 3). Although color measurement may provide finer color distinctions for some materials, questions

Figure 25. These four yellow diamond masterstones (0.39–1.53 ct) mark the most commonly seen lower saturation boundaries of their respective grade ranges (from left to right: Fancy Light, Fancy, Fancy Intense, and Fancy Vivid). The last color grade is a recent addition to the GIA GTL system. Photo by R. Weldon.

Figure 26. All of these diamonds (0.14–0.57 ct) would be graded "Fancy Deep," a recent addition to GIA GTL terminology that encompasses colors of medium to dark tone and moderate to high saturation. Photo by R. Weldon.

have arisen regarding the consistency of such instruments for quantifying the color appearance of faceted diamonds (see, e.g., Collins, 1984) and other gemstones. The many sizes and shapes of fashioned gems influence instrument positioning and path length for light traveling through the stone—and, thus, the accuracy of instrumental color measurements.

An even more fundamental problem is relating the results of instrumental color measurements to the color appearance of faceted gems as observed by eye. Several colorimeters have been marketed for evaluating faceted colorless-to-light yellow diamonds, including the Gran Colorimeter currently being sold by GIA GEM Instruments. If one recalls the factors that influence color observation—the light source, the object, the eye (or, here, the instrument's light detector), and the geometry between these different elements—deriving a consistent set of standards for both visual observation and instrumental measurement of color in gems is a great challenge and, in our opinion, one that has not yet been solved. While instruments such as the Gran Colorimeter do provide useful color measurement data (and can be helpful as back-up for the visual color grading of near-colorless to very light yellow diamonds), the relationship between these data and visual color observations of the same diamond has not been rigorously demonstrated. The challenge is even more profound for fancy-color diamonds. Nevertheless, GIA continues to investigate the use of color measurement instrumentation to supplement visual color grading.

Treated Diamonds. Since GIA GTL first began issuing origin-of-color reports in the 1950s, it has maintained a policy of not color grading diamonds that they have identified as treated. This policy continues today.

Grading Mounted Colored Diamonds. While the most accurate color comparisons are made on unmounted diamonds, practical situations arise that require the color grading of some colored diamonds in mountings. As with mounted diamonds in the "D-to-Z" range, in these instances the color grade is expressed more generally in the form of a range (e.g., "Fancy Light to Fancy yellow") to account for the potential influence of the mounting.

"Additional" Colors. Occasionally, the laboratory encounters diamonds that display an "additional" color that is clearly different from the characteristic color chosen. For example, a blue diamond might contain an orange limonitic (iron oxide) stain in a fracture. In these instances, the additional color component is not included in the color grade but is mentioned as a comment on the laboratory report.

To avoid redundancy in terms (i.e., such as "dark black" or "light white"), natural black and opalescent white diamonds are referred to only as "Fancy" for their Fancy-grade term.

SUMMARY AND PERSPECTIVE

One of the primary goals at the GIA Gem Trade Laboratory is to support the diamond industry with services that protect and enhance the trade, and thus the public trust. That entails a comprehensive program to address all aspects of reporting on the criteria that govern the identification and grading of diamonds. Of significant importance today is the nature of colored diamonds—specifically, their color origin and color grading. This is consistent with the special position that natural-color diamonds have held historically and especially over the last decade (figure 27).

While the "D-to-Z" system used to color grade most diamonds encountered in the jewelry industry (i.e., colorless to light yellow, including light browns and light grays) has been documented, the system used by GIA GTL for colored diamonds has not. Part of the challenge has been to apply scientific, yet practical, time-tested standards to such rarities of nature, and to continuously improve the reporting of such information via laboratory reports.

This article has traced the history and development of GIA GTL's system for describing and grading colored diamonds. This system uses both (1) a controlled viewing and lighting environment to observe the color of faceted natural-color diamonds, and (2) color comparators in the form of colored diamond masterstones and Munsell color chips. These standards help a trained grader identify the characteristic color of a diamond, on the basis of which a descriptive terminology—i.e., a grade—is assigned. The color-grading terminology uses a level-3 fineness, consisting of 27 hue names and possible modifier terms. Supplementing these hue names is a series of Fancy-grade terms that convey information about both the tone and saturation of the diamond's color appearance. The system provided has a basis in color science, yet it is a practical approach to the visual evaluation of colored diamonds.

GIA GTL continues to seek ways to strengthen the system and make it more meaningful. One recent development is the addition of two Fancy-grade terms, *Fancy Deep* and *Fancy Vivid*, to the terminology that will soon appear on GIA GTL reports for natural-color colored diamonds.

Grading the color of colored diamonds is one of the greatest challenges in gemology. The description must be a thoughtful blend of both art and science. GIA GTL's system seeks to use the best of both disciplines, fully describing each subtle color while meeting the practical need to make consistent, repeatable color decisions. It is not an easy process. It requires a robust system with consistent standards. A Fancy yellow diamond must be the same yesterday, today, and tomorrow.

Finally, to neglect history and tradition, or to distance ourselves from the mystique and romance associated with natural-color diamonds, is to do injustice to their beauty. In the end, our responsibility is to study the problem thoughtfully, document the information carefully, and report the results objectively. Recognizing the extremely high values of certain colors in diamond, the system described provides the support necessary to protect and enhance the stability and prosperity of the trade.

Figure 27. Colored diamonds continue to play a special role in the jewelry industry, as they have for hundreds of years. Illustrated here are some jewelry pieces provided by J. & S.S. DeYoung and U. Doppelt & Co. The ring in the lower right contains three Fancy Intense yellow diamonds (1.03, 0.80, and 0.57 ct); the Fancy yellow diamonds in the earrings weigh 7.44 and 7.34 ct, respectively; the nine "greenish yellow-to-green" diamonds in the brooch have a total weight of approximately 21.24 ct; the Fancy Intense orangy yellow oval-cut diamond weighs 1.83 ct; and the 1.54-ct round brilliant-cut diamond is Fancy brownish orangy pink. Photo © GIA and Harold & Erica Van Pelt.

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