

A Consumer Guide to Modern Photo Papers

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As photography has moved from the darkroom to the computer lab, the technologies for printing photos have changed. The age of digital photography has ushered in changes that affect everything from the cost and quality to the look and feel of photographs being printed today. In order to make the best decisions for purchasing photo papers or, at the very least, to understand why some modern photos don't look or feel like those of only a decade ago, consumers need to understand the modern digital print papers.

While we can now print photos on mugs, mouse pads, blankets, and just about anything else you can image, this guide will discuss only images printed on plain paper or laminated papers. In some cases, paper type can influence image quality, print durability, and image permanence; however, the *quality* of a specific paper within each of the paper types described below can have an even greater effect. Because this is such a complex area, this guide will not address these issues deeply. The permanence of these modern images is discussed in IPI's *A Consumer Guide to Traditional and Digital Print Stability* (see back page for more information). Additionally, this guide is not intended to provide information on product cost or value. Some inexpensive papers will produce poor-quality photos; however, it is up to the consumer to decide on trade-offs between quality and cost for the intended application.

A BRIEF HISTORY OF PHOTO PAPERS

Papermaking was invented in China around 105 A.D. It didn't make its way to Europe until over a thousand years later, and it didn't come to the Americas until the late seventeenth century. Paper is composed mainly of plant fibers. Today it is usually made with wood fibers, but it may also be made with cotton or other materials. In wood pulping, wood chips are either mechanically mashed into pulp (groundwood pulp) or soaked in chemicals to separate the fibers (chemical pulp). This pulp is sometimes bleached to improve its whiteness. Finally, the pulp is mixed with water and spread thinly on a screen to form sheets.

To improve the properties of paper, substances such as clay can be added to make the paper denser and more opaque. Adding a chemical called *sizing* makes the paper water resistant and easier to write or print on. Paper can also be pulled through heavy rollers to make the surface very smooth in a process called *calendaring*. It is from writing and printing papers that photo papers were eventually manufactured.

For the last 150 years the term *photo paper* has been used to describe light-sensitive papers used to create photographic prints. Nineteenth-century photo papers were usually handmade. Plain papers or papers coated with a clear binder layer were sensitized with special salts and silver nitrate. They could then be exposed to light either directly or through a negative. The earliest papers didn't need "development," but they did need a chemical bath that fixed the image by removing the light-sensitive salts in unexposed areas of the print. They were then washed to remove the fixing chemical and prevent yellowing and staining of the photo over time. The difficulty of sensitizing papers by hand and the expertise required usually limited photography to professionals and dedicated hobbyists.

Two advances near the end of the nineteenth century brought photography home to everyone. The first was the mass manufacture of photo papers. Photo papers no longer needed to be sensitized by hand but could be purchased pre-sensitized in a box. Secondly, new photo papers were invented that had to be chemically developed. This additional processing step reduced exposure time from minutes to less than a second. Now photographs could be printed quickly in large quantities; thus the commercial photo lab was born. Eventually, photo-paper technology advanced to include color photography.

In the late sixties, photo papers began to be manufactured with a plastic (polyethylene) laminate on both sides of the sheet. These papers are called resin-coated or “RC” papers (see Figure 1). The laminate was added to keep the print flat after wet processing and to reduce the processing time, as less wash is needed. The top layer of laminate is often pigmented white to make the image a very bright. The back layer is clear. Historically, the term *RC print* only referred to wet-processed photographs; today, however, RC paper is also used in the manufacture of dye-sub and many inkjet photo papers. This is done to give these digital printing papers the look and feel of photos of years past.

With the advent of digital photography, the term *photo paper* no longer exclusively means light-sensitive papers. It still includes them, but it also encompasses a variety of other papers, all designed to have a pictorial image printed on them.

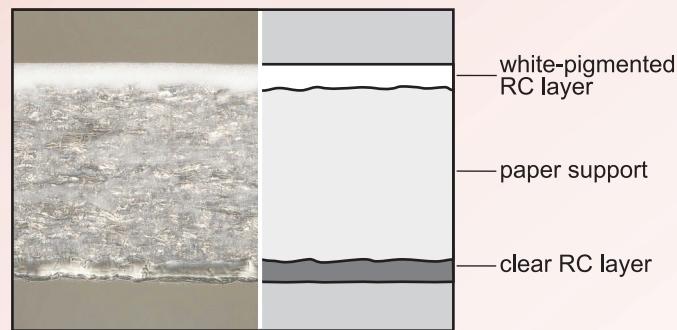


Fig. 1 Magnified cross-section of resin-coated (RC) paper with white-pigmented layer on top and clear layer on bottom.

PHOTO PAPER CHARACTERISTICS

Photos consist of at least two components:

- **Paper**—This can include thin sheets of plain paper, like that used to create office documents (see Figure 2), or thick, multi-layered papers, such as the RC type described above.
- **Image-forming materials**—These are the colorants that actually make up the picture. Image-forming materials include dyes, pigments, and toners.

Most photos will have a third component: **a binder or ink receiver layer**. Specialty photo papers have a clear binder or ink receiver layer applied to the paper to hold the image above the paper surface.

Photo papers have a variety of characteristics that affect how they look and feel. Some papers are available in only one type and others come in a number of variations. Understanding these will help you choose the photo paper that best fits your needs.

- **Thickness/basis weight**—Every photo paper has its own thickness and stiffness. From plain paper to heavy, almost cardboard-weight fine art papers, photo papers are designed not only to look a certain way but also to feel a certain way. Fine art papers are often sold in different basis weights, such as grams per square meter (g/m²). The higher the number, the thicker and heavier the paper will feel. For comparison purposes, a typical office paper is 80 (g/m²).
- **Texture**—Texture usually refers to the fibrous look and feel of the paper. Some papers are not intended to look and feel like traditional photo papers but more like watercolor paper or art canvas.
- **Surface sheen**—Surface sheen refers to the reflectivity of the paper coating. This ranges from matte to high gloss, with variations in between. This term is typically used to describe traditional photos or digital photos intended to look and feel like traditional photos.
- **Base tint**—Some papers are tinted to create a pleasing color. Titanium dioxide or barium sulfide might be added to make the paper very white or a dye might be added to make the paper look off-white or cream-colored.
- **Optical brightening agents**—Photo papers are often treated with special dyes to further brighten the white areas of the picture. These are called optical brightening agents (OBA). They work by converting invisible UV energy into visible light. This makes the picture seem brighter. The image in Figure 3 was photographed using UV light. The glow indicates the presence of optical brighteners. Optical brighteners



Fig. 2 Magnified cross-section of plain office paper.

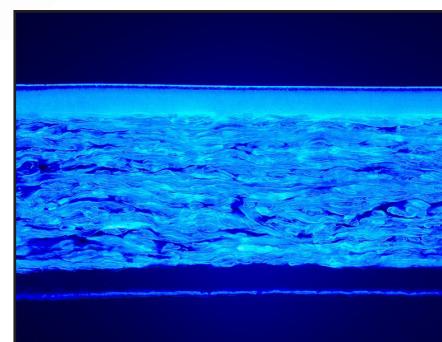


Fig. 3 Magnified cross-section showing fluorescence of optical brightening agents under UV light.

are somewhat controversial. Most photo papers have them because extremely bright white papers are popular. However, OBAs can degrade more quickly than regular dyes, resulting in a dull, even yellowed, photograph long before the picture fades.

The product package often specifies paper characteristics in a table similar to the one shown here. The presence of OBAs is usually not listed; it is often possible to determine if they are present by viewing the paper under a “black light.”

PHOTO PAPER TYPES

With the exception of plain papers, all photo papers are tied to their printing technologies. For example, an inkjet photo paper cannot be printed using a dye-sub printer, and vice versa. Below are descriptions of the various paper types grouped by printing technology.

Traditional (Wet-Processed) Photo Paper

Today, wet-processed color photo papers are used to print photos from digital files. These papers are RC papers with a clear gelatin top coat. The image-forming dyes are developed within the gelatin layer during processing. These papers are light sensitive and can be printed either by computer-controlled lasers from digital image files or by traditional negative exposures on an enlarger. Figure 4 shows a cross-section of a wet-processed photo paper. The image-forming dyes suspended in the gelatin binder form the dark layer at the very top. Currently, traditional photo paper prints can be obtained from photo processing labs, online photo services, and photo kiosks where the prints are not produced instantly but ordered for later pick-up.

Dye-Sub Papers

Dye-sub, dye-sublimation, or, more technically correct, dye diffusion thermal transfer (sometimes referred to as D2T2) printing papers are those typically used in instant-print kiosks and many small 4" x 6" snapshot-size printers (although both printer types can also use inkjet technology). This is the modern photo paper that most resembles a traditional wet-processed photographic print. These papers are not light sensitive. In the dye-sub process, image-forming dyes carried on colored donor ribbons are transferred onto the paper by heat, one color at a time. A clear coating is then applied to protect the image from handling and atmospheric pollutants that could cause fading. Figure 5 shows a cross-section of dye-sub photo paper.

Laser Printing

Laser printers are part of a class more correctly known as electrophotographic printers and include both consumer desktop versions as well as large commercial digital presses. They actually use the same technology as photocopiers, but, instead of reflected light from an original document in a copier, they use a laser to create the image from a computer file. The laser exposes a charged metal drum or belt inside the printer. Black or colored toner particles are attracted by electrostatic charge to the imaging drum, and the image is then transferred to the printing paper. Finally, the toner is fused by heat and pressure to the paper surface to make it permanent. Laser printers are most commonly used for text documents, so readability is the major concern. The papers are usually calendered to prevent the texture of the paper

Product Specifications
Weight 285 g/m ²
Glossy
Bright White
Letter size
50 Sheets

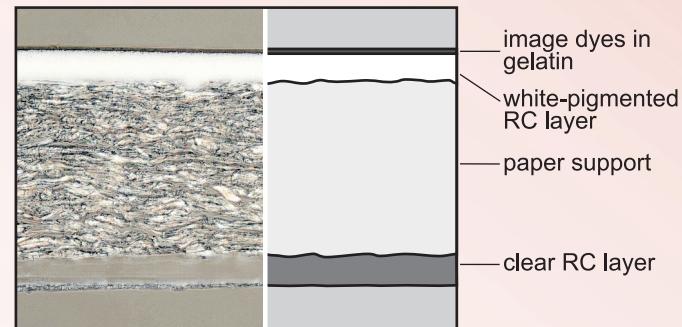


Fig. 4 Magnified cross-section of wet-processed photo paper

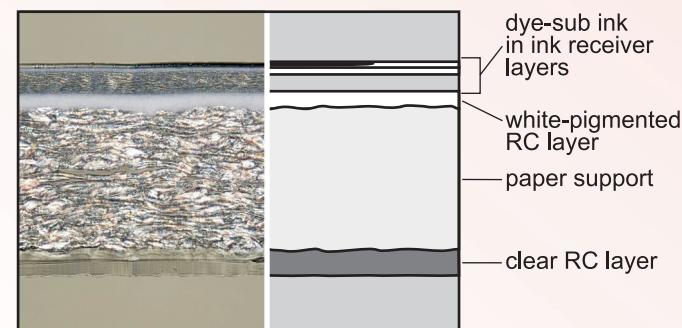


Fig. 5 Magnified cross-section of dye-sublimation photo paper

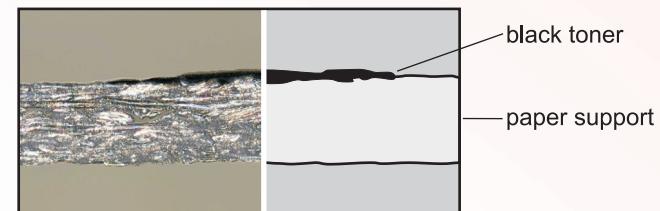


Fig. 6 Magnified cross-section of laser print on plain paper

fibers from disrupting the readability of the printed text. Laser can also be used to print photographs, particularly when images are included within a text document. However, image quality is low with desktop laser printers.

Most laser printers use plain paper, also called office paper or copier paper. A major disadvantage of plain paper for photos is that it is thin and easily bent or torn while handling. Also because laser printer papers are not resin-coated they do not feel like traditional photographs. Figure 6 shows a cross-section of a laser print. The fused toner particles are clearly visible on top of the paper.

Inkjet Photo Papers

Inkjet papers are the most varied and complex of all digital photo papers. These papers are all optimized for use with inkjet printers, which use liquid inks that are sprayed out in a stream of drops onto the paper according to the data in the image file. While this process holds true for all inkjet printers, there are two types of ink: dye and pigment. Whether a printer uses dye or pigment inks determines what kinds of papers may or may not be used. Most home printers and some store kiosks are inkjet.

Inkjet Photos on Plain Paper

While plain paper is used extensively with inkjet printers to create text documents, inkjet on plain paper can be problematic when printing images. This is because inkjet ink is water-based. Only a small amount of ink is applied during document printing, but large amounts of ink are needed for printing images. This amount of ink soaks the paper and causes it to wave and cockle. Another problem is that the ink can spread slightly when absorbed into the paper surface. This can make colors appear both lighter and duller and the image less sharp. There are some special plain papers available for inkjet printers that reduce the amount of ink spread and these associated problems. The package label will state that the paper is intended especially for inkjet printers. However, pictures will be only slightly better in terms of color and sharpness. To print high-quality photos, swellable or porous photo papers are needed.

Swellable Inkjet Coated Paper

The swellable photo coating on inkjet papers swells and absorbs the liquid ink sprayed onto it by the printer. These papers are for use only with dye ink sets, as pigment inks cannot be absorbed into the coating. One advantage of these papers is that they can be much glossier than porous papers. Also, because the ink is absorbed into the swellable layer, the prints are more resistant to abrasion or fade from airborne pollutants. These papers are becoming less popular because they can take from several minutes to several hours to dry. Handling the prints while they are wet can lead to smearing of the dye. Most manufacturers are switching to the porous paper types, which dry instantly. Figure 7 shows a cross-section of a dye inkjet print on swellable coated paper. The ink can be seen absorbed into the thin top coating.

Porous Inkjet Coated Paper

The term porous inkjet paper really refers to three sub-types: macro-, micro- and nanoporous papers. They are similar in that they all have small pores that absorb the ink; they differ in the types of chemicals used to make the coatings and in the size of the pores. The main advantage of the extremely tiny nano-pores is that the paper will appear glossier than macro- or nanoporous papers, but nanoporous papers are more difficult and expensive to produce. Porous inkjet paper is basically a thin layer of mineral particles held to the paper by a polymer binder; the inks are sprayed into the top layer of these pores to form the image. The water from the ink is quickly drawn down further into a second, deeper layer of pores resulting in an “instant dry” print. Figure 8 shows a cross-section of an inkjet print on porous paper.

Porous photo papers can be used with both dye and pigment inkjet printers. One disadvantage is that while nanoporous papers are often advertised as glossy, they are not as glossy as swellable inkjet, dye-sub, or traditional glossy photos.

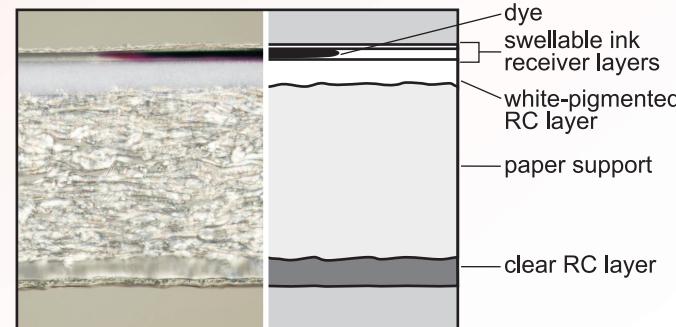


Fig. 7 Magnified cross-section of swellable inkjet photo paper

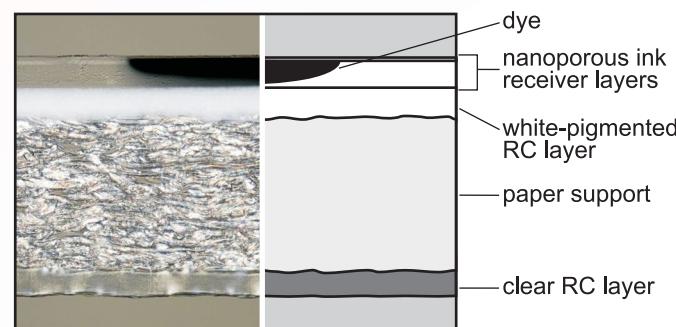


Fig. 8 Magnified cross-section of porous inkjet photo paper

Many porous inkjet papers are laminated with the same RC layers as traditional photo paper so that they too look and feel like traditional photos; however, there are a number of specialty porous photo papers that do not have the plastic laminate. These are usually referred to as fine art papers.

Unfortunately, most paper manufacturers do not state whether their products are of the swellable or porous type. Sometimes the information can be found on their websites. Here are a few hints, though. Most, if not all, papers labeled as “instant dry” will be porous. Swellable papers will be listed as fast-drying, and they may be labeled “high gloss” rather than just “gloss.” This is because swellable papers can be made glossier than porous papers.

Fine Art Inkjet Paper

While many fine art inkjet papers are of the swellable or porous type with resin coating, a considerable number of specialty fine art papers for inkjet more closely resemble watercolor or other art papers. Some artists use standard art papers, but, as with plain office papers, the colors will appear dull and the images less sharp. For this reason, some paper companies have created art papers with special inkjet receiver coatings. The receiver coatings are usually capable of accepting both dye and pigment inks. Figure 9 shows a cross section of a fine art photo paper for inkjet. Notice the ink within the porous coating and the absence of RC layers.

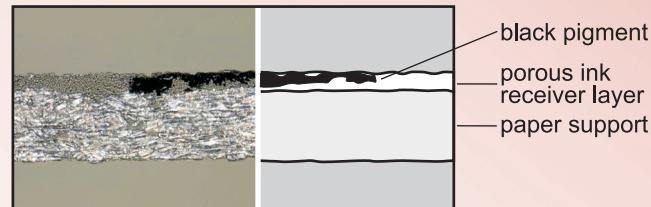


Fig. 9 Magnified cross-section of fine art porous inkjet photo paper

PRINTING WITH MODERN PHOTO PAPERS

Printing at Home

When printing digital images from a home computer, your software package will usually offer a variety of printer settings to ensure good print quality. These settings tell the printer what type of file is being printed (whether text or photo), what size the paper is, and what type of paper is being used. The computer uses this information to apply the correct colors, mixture of colors, and volume of ink to the paper. Plain papers absorb a lot of ink and therefore need more ink than coated papers. Too little ink on a plain paper will result in an image that is too light. Too much ink on a coated paper will cause ink pooling.

Printer and paper instructions should also be followed for dry times for inkjet prints. The inks are liquids whose solvents need to evaporate before prints are handled or put in an album. This dry time will vary, generally from instantly to about 24 hours, and is usually specified on the paper packaging. Even if a print is supposed to be instant dry, it may be a good idea to let it dry longer before putting it inside an album, sleeve, or envelope, especially if that enclosure is plastic.

Store Kiosks

Many shops, from independent photo retailers to the corner drug store, now have photo kiosks. These computer stations are used to take customer orders for a variety of photo products: prints, posters, calendars, etc. It is possible to get any of the four print types from kiosks. Most kiosks that advertise instant prints use dye-sublimation papers. A few use inkjet, though, and that may become more common in the future. Many kiosks that take your order for later delivery use traditional wet-process printing to create the photos. However, that is not always the case for posters, calendars, and photo books; many of those will be printed on industrial-sized laser printers called digital presses. It might be a good idea to ask for sample prints at the store to make sure you are getting paper with the look and feel you want.

Printing Online

The types of paper used for online printing are generally the same as those used at store kiosks, with the exception of dye-sublimation. Because dye-sub is typically more expensive, and because instant printing is not necessary for these labs, online printing services tend not to use it. One hazard of online printing is that you can't ask for samples to determine if you like the paper before ordering. If one company prints on a paper you like, you won't necessarily get the same paper if you order from another site.

Photo Books

All of the photo paper types described here can be used in the printing of photo books. Photo books can be created at home, at retail outlets, or online. Most at-home photo book kits will be created with inkjet prints. Commercial photo book suppliers use all types of printers to create their books, although the predominant process at this time is laser. Traditional, dye-sub, and most home inkjet photo papers can be printed on only one side at a time. Another thing to

be aware of is that traditional, dye-sub, and swellable inkjet prints can stick together if they are facing one another in a book. Laser prints do not exhibit the problem of sticking; but the quality of home laser printers isn't yet as good as commercial laser or dye-sub printers.

Commercial printers can use high-speed digital printing presses using the same technology as laser printers but with better image quality. They have the added advantage of being able to print on both sides of the page, making the final product more book-like. Again, if purchasing a photo book from a commercial source, it would be wise to ask for page samples to make sure you get the paper you like.

CONCLUSION

While wet-processing of photographic images is still common, several new technologies for printing photographs have appeared: inkjet, dye-sub, and laser. New photo papers were needed for the new technologies. Some of the new photo papers have been designed to mimic the physical characteristics of the old-style wet-processed photos, while others have been designed with new textures and tints to give more choice and creative options to the consumer. In addition, printing now can be done at home, at retail outlets, or online, offering greater convenience and control and a wide range of prices. Just remember—when ordering prints or buying photo paper for your home computer, ask for sample prints to make sure the photos you get have the look and feel you want.

MODERN PHOTO PAPERS: ADVANTAGES AND DISADVANTAGES

Process	Paper	Primary Use	Advantages	Disadvantages
Traditional Wet-process	Light sensitive	Photos	Long history.	Complicated to process.
Dye-sub	Dye-sub specialty paper	Photos	Looks and feels just like traditional photo.	Few sizes. More expensive.
Laser	Plain	Documents	Inexpensive. Fast printing.	Low image quality. Easy to bend or tear.
	Plain, treated	Documents	Inexpensive. Fast printing. Better image quality.	Image quality still lower than other processes. Easy to bend or tear.
	Plain, coated	Photobooks	Good image quality on digital press for photo books.	Low image quality on home printers. Easy to bend or tear.
Inkjet	Plain	Documents	Fast printing.	Ink spread results in dull, unsharp image. Easy to bend or tear.
	Plain, treated	Documents	Fast printing. Better image quality.	Image quality still lower than photo-specific papers.
	Swellable	Photos	High image quality. Very glossy.	Less frequently sold. Slow drying. Can't be used with pigment inks.
	Porous	Photos	High image quality. Instant dry. Can be used with dye or pigment inks.	Not as glossy as swellable. More sensitive to abrasion and fade.
	Fine Art	Photos	Wide variety of choices. Unique textures and colors.	Image quality not as good as swellable or porous. Very sensitive to abrasion.

GLOSSARY

Binder—The term commonly used to describe the clear gelatin layer on a traditional wet-processed photograph. The colorants that form the picture in a traditional photo are present in the binder layer during manufacture. The term binder is less applicable to modern photo papers. Instead, the term *ink receiver layer* is preferred, as inks are applied to the paper surface during printing.

Chromogenic or “C” print—The form of almost all wet-processed, consumer color photographic prints. In this process, the image-forming dyes are created during processing from colorless dye couplers included in the paper during manufacture. See also **Wet-processed print**.

Cockle—Wavy distortion of a paper due to exposure to water or high humidity.

Dry-time—Time from the moment the image is printed until the ink’s liquid solvent (usually water) has evaporated.

Dye-sublimation print—Also called *dye-sub*. Technically known as dye diffusion thermal transfer (D2T2), this printing technique uses heat to diffuse dyes from colored donor ribbons onto the print paper. The intensity of the color is controlled by variations in temperature on the printer head. The final step is the application of the clear overcoat to protect the image from handling and atmospheric pollutants.

Direct dye thermal transfer (D2T2) print—See **Dye-sublimation print**.

Electrophotographic print—A print made by colored toner transferred to paper by electrostatic charges. The charges are created in the pattern of the image by an intensity modulated laser. The print is then fixed to the paper by heat or pressure or both.

Giclée—A high-quality fine art print created with an inkjet printer.

Indigo print—An electrophotographic print made with HP’s Indigo liquid-toner, digital press.

Inkjet print—A print made by tiny droplets of ink which are jetted onto the paper’s surface. See also **Giclee**.

Ink receiver layer—See **Binder**.

Kiosk (photo)—A self-serve station in retail outlets that permits customers to order prints from digital files or from prints via a built-in scanner.

Laser print—See **Electrophotographic print**.

Photo book—A collection of photographs bound together in book form. This is different from a photo album where loose photos are attached to or inserted into already bound blank pages.

Plain paper—Typical office copier paper.

Porous print media—Inkjet printing papers in which the ink receiving layer is formed by minerals (silicas or aluminas) bound by polymers to create microscopic pores to absorb printer ink.

Resin-coated paper (RC paper)—A paper that has been coated with polyethylene film on both sides to keep the sheet flat and reduce wash times during wet processing. Many modern inkjet photos use resin-coated papers to recreate the look and feel of traditional wet-processed photographic prints.

Sizing—A natural or synthetic substance added to the paper pulp or to the surface of the paper sheet to impart water resistance and a smooth surface for writing.

Swellable print media—Inkjet printing papers in which the receiving layer is a moisture-sensitive polymer. The polymer swells in contact with water-based ink and absorbs the dye droplets. This provides the dyes with some protection from air pollutants or abrasion.

Thermal print—See **Dye-sublimation print**.

Toner—Dry or liquid coloring substance used in laser printers, photocopiers, and digital presses.

Wet-processed print—A photographic print processed by a liquid chemical procedure to amplify and fix the latent image on a light-sensitive paper.

Xerography—See **Electrophotographic print**.

MODERN PHOTO PAPERS FAMILY TREE

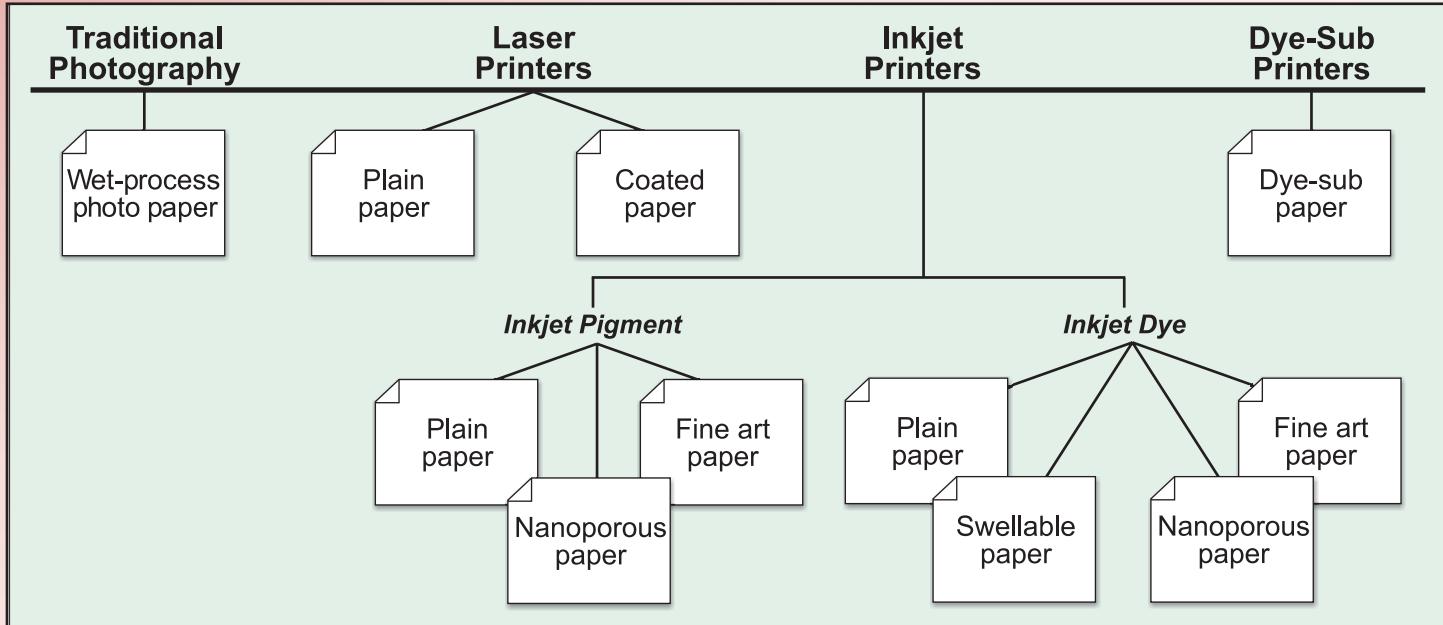
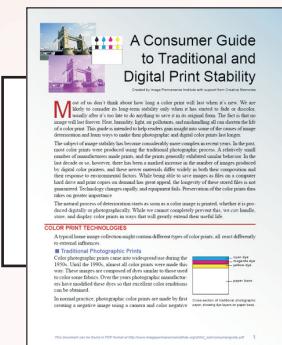


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This eight-page guide offers insight into some of the causes of image deterioration and suggests ways to make photographic and digital color prints last longer.

Can be downloaded as a PDF at www.imagepermanenceinstitute.org (click on "Downloads"). The free printed booklet is available on request.



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