Notes:
* dyeing occurs when the fibers are still in semi-solid stage (gel) in wet spinning
** dyeing occurs between fiber and yarn stages.
Solution Dyeing

- **Solution** dyeing, known as *dope* or *spun dyeing*, is the process of adding color to the solution before it is extruded through a spinneret.

- Used for difficult-to-dye, manufactured fibers such as olefin, and for end uses requiring excellent colorfastness.

- Used for environmental reasons as it reduces the need for energy, water, and waste water disposal.

- Color pigments are part of the fiber, creating materials with **excellent colorfastness** to light, washing, crocking (rubbing), perspiration, and bleach.

- **More expensive** due to initial set-up costs. It is difficult to stock each color; color decisions must be made early in the manufacturing process.

- The colors/shades available have increased. Several solution dyed fibers are available for apparel and home furnishings.
Pellets with Green Pigment Used to Manufacture Solution Dyed Olefin Fibers for Artificial Turf

Courtesy Atexinc Inc.
Note: Solution dyed and dope dyed are used interchangeably. As solution dyed filaments are extruded through a spinneret and wound as yarn onto a package, the term solution dyed yarn is used. For example, in this yarn solution dyed filament fibers that were extruded through a spinneret with 72 holes were stretched and wound to form a solution dyed yarn.

Sample courtesy Eastman Chemical Company
SpunShades™ Solution Dyed, Viscose Rayon Fibers

Note: Pigments are used for solution dyeing. SpunShades™ solution dyed, rayon fiber is used for end use applications that range from infant wear to upholstered furniture. Solution dyed rayon has excellent colorfastness properties and is produced using an environmentally friendly process (it eliminates the need for the wet processing step to add color). SpunShades™ fibers are Oeko-Tex® 100 certified.

Samples courtesy Birla Cellulose, manufacturers of SpunShades™ rayon.
Gel Dyeing

- **Gel dyeing** is used only for fibers produced by wet spinning; the color is added in the chemical bath after fibers have been extruded through a spinneret.

- Gel dyeing is used for acrylic fibers colored with cationic dyes.

- The initial set-up is much simpler than for solution dyeing as the fiber is extruded and then colored.

- Other advantages and disadvantages are similar to those of solution dyeing.
Stock dyeing, top dyeing, and tow dyeing occur at various stages of manufacturing, **prior to the fibers being spun into yarns**. The names refer to the stage at which the fiber is dyed:

- **Stock dyeing** is dyeing raw fibers (stock) before they are aligned, blended, and spun into yarns.

- **Top dyeing** is dyeing worsted wool fibers (top) after they are combed to straighten and remove the short fibers; it is preferred for worsted wools as dye is not wasted on short fibers.

- **Tow dyeing** is dyeing filament fibers (tow) before they are cut into short staple fibers.
Wool Fibers Hand Dyed with Acid Dye
Fiber Dyeing

Stock, top, and tow dyeing:

- Dye penetration is excellent; the amount of dye used at this stage is higher.

- Color decisions must be made early in the manufacturing process; the processes are not suitable for “quick response” products.

- The processes are more costly than yarn, fabric, and product dyeing.

- **To produce yarns with two or more colors**, wool and other fibers are fiber dyed. Tweeds and fabrics with a “heather” look are fiber dyed fabrics.

- Naturally colored fibers in black, grey, and tan wool tweeds, as well as cross dyed materials, can be mistaken for fiber dyed materials.
Dyed and Undyed Wool Fibers Blended To Create a Heather Look
Yarn Dyeing

- In **yarn dyeing** color is added after the yarn has been manufactured.

- Yarn dyeing provides adequate color absorption and penetration. Thick yarns (e.g., denim yarns) may not have good dye penetration.

- Dyed yarns produce woven and knitted fabrics requiring colored yarns to create a design (e.g., stripes, plaids, checks, iridescent).

- Yarns for hand weaving, knitting, crocheting, and weaving are yarn dyed.

- Some knitted garments, especially those made of manufactured fibers, are produced with dyed yarns. It is often difficult to determine if the solid colored knitted garments were yarn dyed, product dyed, or produced with naturally colored fiber.
Yarn Dyeing – Skein dyed novelty yarns used for hand knitting and weaving
Yarn Dyeing – Front panel of a sweater produced with acrylic yarn dyed prior to knitting

Note: Solid colored, full-fashioned sweaters can be yarn or product dyed. Fiber content, cost, and colorfastness characteristics are some of the factors considered for dyeing.
Yarn Dyeing

- In **skein dyeing**, yarns are loosely wound into hanks or skeins and then dyed; dye penetration is good, but the process is slow and more expensive.

- In **package dyeing**, yarns wound on perforated spools are dyed in a pressurized tank; the process is faster, but dye uniformity may not be as good as in skein dyeing.

- In **beam dyeing**, a perforated warp beam is used instead of spools as in package dyeing.

- **Continuous dyeing** is a method in which the dyeing, fixation of dyes, and washing is done as a continuous process. It is used for dyeing large quantities of yarns for denim with indigo and/or sulfur dyes.

- In **space dyeing**, skeins are dyed in multiple colors.
Package Dyeing

yarn on perforated cone

Source - Dictionary of Fiber and Textile Technology
Figure adapted with permission

yarn on perforated cone

Photographed with permission of Reliance Dyeing Works
Note: Yarns are wound on perforated tubes to allow liquid dye to be pumped into the packaged yarn.

Photographed with permission of Reliance Dyeing Works
Indigo Dye Range – Continuous dyeing of denim warp yarns

Note: This picture was taken of dyed warp yarns that are being rinsed to remove excess dye.

Courtesy American Cotton Growers
Space Dyed Yarn

Photographed with permission of Reliance Dyeing Works
Fabric or Piece Dyeing

- In fabric dyeing color is added after the fabric has been constructed.
- Several types of batch and continuous dyeing machines are used; the selection is based on factors such as dye and fabric characteristics, cost, and the intended end use.
- Fabric dyeing is very economical; it is the most common method of dyeing solid colored fabrics.
- Color decisions can be made after a fabric has been manufactured, so the process is suitable for “quick response” orders.
- Dye penetration may not be good in thicker fabrics; yarn dyeing is sometimes used to dye thick fabrics in solid colors.
- Note: Product dyed or solid colored fabrics manufactured with naturally colored fiber, materials, or yarn may be mistaken for piece dyed fabric. Check fiber content and pull a yarn to check dye penetration to assist in determining whether a fabric is piece dyed.
Poor Dye Penetration in a Heavyweight Piece Dyed Fabric
Methods of Fabric or Piece Dyeing

Beck/winch and jet are methods in which the fabric is dyed in a rope form. The two ends of the fabrics are stitched to form a continuous loop of fabric.

- **Beck/winch dyeing** is typically used for dyeing fabrics that do not need high pressure and temperature for dyeing. A reel located at the top of the machine is used to move the fabric. Dyeing occurs while the fabric is in the dyebath. This machine is also used for washing and pretreatments.

- **Jet dyeing** is often used for dyeing fabrics that need high pressure and temperature for dyeing. In jet dyeing, the dye liquid and the fabric move through the enclosed unit. Woven as well as knitted fabrics are dyed in jet dyeing machines. The type of jet dyeing machine is selected based on the fiber content and type of fabric to be dyed.
Note: Beck/winch machines are used for dyeing and washing. In this photograph velvet fabric is being rinsed after dyeing.

Photograph courtesy Taj Velvet & Silk Mills
Note: Jet dyeing machines are available in different shapes and sizes. This is a schematic of a machine with a circular cross-section.
Jet Dyeing – High pressure, high temperature piece dyeing

Note: Several types of machines, of different shapes and sizes, are used for jet dyeing. Factors such as fabric construction, fabric weight, and desired fabric hand are taken into consideration when selecting the machine.
Methods of Fabric or Piece Dyeing

Jig, beam, pad and continuous dyeing are examples in which the fabric is dyed in an open-width form.

- **Jig dyeing** machines consist of two rollers on either end of the machine and the dye bath at the base. Fabric is dyed by moving the fabric from one roller into the dyebath and then up to the second beam. Jig dyeing is typically used for woven fabrics using either open atmospheric conditions or an enclosed pressurized environment.

- **Beam dyeing** is a method in which the fabric is wound on a perforated beam and the dye liquid forced through the holes to dye the fabric. Beam dyeing is suitable for fabrics that require special care as the fabric remains stationary.

- In **pad dyeing** the fabric passes through a trough with dye solution with an alkali and then between two heavy rollers that force the dye into the fabric as well as squeeze out extra dye solution. The dye in the fabric is allowed to set prior to rinsing and drying. This method is relatively eco-friendly as it requires less water and energy for dyeing.

- The **continuous dyeing** process is often used for piece dyeing of cotton/polyester blend fabrics.
Jig Dyeing

fabric moves back and forth from one roller to another

dye bath

Source - Dictionary of Fiber and Textile Technology
Figure adapted with permission
Beam Dyeing – Pressurized piece dyeing on a perforated beam

Photographed with permission of Colorama Dyeing & Finishing
Pad Dyeing

Photographed with permission of Pratibha Syntex Ltd.
Product Dyeing

- **Product** or *garment dyeing* is for completed items such as hosiery, wool berets, T-shirts, and sweaters.

- The process is suitable when all components (including threads) dye the same shade; for example, sheer pantyhose are knitted, stitched with thread that dyes to the same shade, and then dyed.

- The process is not commonly used for apparel with many components (lining, zippers, and sewing thread); each component may dye differently. Examples of exceptions are tinting jeans for a “vintage” look and dyeing of denim jeans made with cotton and cationic cotton yarns.

- Product dyeing is **ideal for quick response**. T-shirts, sweaters, and other casual clothing are product dyed for fast response to demand for certain popular colors. Thousands of garments are constructed from prepared-for-dye (PFD) fabric, and then dyed to colors that sell best.
Product Dyed 100% Cotton Denim Jeans with Protura™ Cationic Cotton Warp Yarns and Regular Cotton Filling Yarns

Note: These are examples of cotton jeans before and after dyeing. The jeans were stitched with yellow thread typically used for denim jeans. When dyed, the Protura™ cationic yarns accepted the dye.
Product Dyeing

Paddle and rotary drum dyeing machines are typically used for product dyeing. Note: High-volume carpet dyeing is typically done on special continuous dyeing machines designed primarily for carpets.

- **Paddle** dyeing machines are available in different sizes and designs. A paddle mechanism is used to move the garments/items and the dye solution. In some machines the paddle is on the side of the machine. Note: Mesh bags are used to dye delicate items that require special handling.

- A **rotary drum** machine consists of a perforated drum that holds the garments or products to be dyed. The drum is often divided into sections for easier handling. Garments or products are dyed as the dye solution moves through the perforated drum as it rotates.
Paddle (Product) Dyeing

- Paddle
- Drain
Product Dyeing – Front view of a side paddle dyeing machine (paddle is located at the back of the machine)

knitted products circulate with the dye solution

Photographed with permission of Dorothea Knitting Mills
Product Dyeing – Rotary Drum Dyeing Machine

Note: This is an example of a product dyeing machine used for pigment dyeing of garments. It is also used for garment finishing.

Photographed with permission of Ajax Textile Processing Company
Union Dyeing

- **Union dyeing** is “a method of dyeing a fabric containing two or more types of fibers or yarns to the same shade so as to achieve the appearance of a solid colored fabric” (Source - *Dictionary of Fiber and Textile Technology*).

- Fabrics can be dyed using a single- or multiple-step process.

- A combination of disperse and reactive dyes is used to dye cotton/polyester blends.

- Union dyeing is **used to dye solid colored blends** and combination fabrics for apparel and home furnishings.
Union Dyeing (Cotton/Polyester Blend)
Cross Dyeing

- **Cross dyeing** is “a method of dyeing blend or combination fabrics to two or more shades by the use of dyes with different affinities for the different fibers” (Source - *Dictionary of Fiber and Textile Technology*).

- Cross dyeing is used to achieve looks for which fiber or yarn dyeing would typically be required. Although cross dyeing is typically used for piece dyeing, it can also be used for product dyeing.
  - A heather look is achieved by dyeing fiber blends with dye that has an affinity for only one of the fibers. Blends of same fiber with different dye affinity can be cross dyed.
  - Plaid, check, or striped fabrics are produced by using yarns with different dye affinity.
  - An interesting example is using cross dyeing to create blue, worsted wool fabric with white polyester pin stripes. When dyed, the wool yarns take up the blue dye, while the polyester yarns, which have no affinity for the dye, remain white.

- Cross dyed fabrics are typically mistaken for fiber or yarn dyed materials as the fabric is not a solid color, a characteristic considered typical of piece dyed fabrics.
Cross Dyeing - 100% cotton socks made with cotton and cationic cotton blend

Note: These socks were knitted with Protura™ yarns manufactured by blending cotton and cationic cotton fibers. When the socks were dyed, the cationic cotton fibers were colored, giving product dyed 100% cotton socks a heather look.
Cross Dyeing - Silk warp and linen filling

original sample

dyed sample
Cross Dyeing – Dark blue worsted wool suiting with white polyester fibers used for the pinstripes

Note: This is an example of cross dyeing being used to reduce cost. Use of polyester yarns for the pinstripes enables piece dyeing instead of yarn dyeing (piece dyeing is cheaper).