Ancient handmade materials such as tapa (or bark cloth) and felt were the forerunners of modern nonwovens.

- Tapa is a traditional cloth from the islands in the Pacific Ocean that is made by hand, using strips of inner bark from the mulberry tree.

- True felt is made with wool and wool blends. True felts are produced by matting fibers using moisture and friction.
  - Wool felt is used extensively for molded hats.
  - It is used by fiber artists to create handmade items.
  - Hand felted fabrics are used for traditional rugs, jackets, hats, shoes, blankets and other items.
This traditional Polynesian cloth is made by hand. Strips of the inner bark of the 
flipberry tree are soaked, scraped, and then beaten to tissue-paper thickness. Sheets 
of this material are wetted, superimposed, overlapped, and beaten again to make a 
large piece of tapa. The cloth is then hand painted using natural pigments.
Wool Felt

wool fibers burn to form a crushable bead

magnified view
Wool Felt Hat

Note: Molded hats are commonly made with felted wool. This hat made with high quality wool felt was molded and then decorated with feathers and rhinestones.
Traditional Felting Method Used to Produce Wool/Cotton Namdah Rug
Nonwoven Fabrics

- **Nonwoven fabric** is “a manufactured sheet, batting, webbing, or fabric that is held together by various methods, e.g. thermal fusion, resin and solvent bonding, or mechanical interlocking of fibers, sometimes concurrently with their extrusion.
  - The term is sometimes used broadly to cover other structures such as those held together by interlacing of yarns (stitch bonding) or those made from perforated or porous films.
  - The term excludes woven, knitted, and tufted structures, paper, and felts made by wet milling processes.”

* Source - *Dictionary of Fibers and Textile Technology.*
Nonwoven Fabrics

- Nonwoven fabrics are typically less expensive to produce than wovens or knits.

- Nonwovens are used to manufacture disposable products for the medical, hygiene, and food industries.
  - Product knowledge is important for selecting nonwovens for hygiene and food use, as it affects the health and safety of users.

- Nonwovens are used to manufacture products such as carpet backing, protective clothing, fiberfill, window shades/blinds, and geotextiles.

- Manufacturing nonwovens requires formation and bonding of a fiberweb.
  - The bonding process used to hold a web together is determined by fiber content, web formation method, and intended end use.
Medical Applications - Disposable bootie used in hospitals

Magnified view
Tea Bag Made of Nonwoven Fabric

Magnified view
Winter Glove with Thinsulate™ Interlining – Thinsulate™ is a meltblown nonwoven fabric
Nonwoven Olefin Fabric – Tyvek used as moisture and wind barrier
Web formation depends on fiber length.

- **Staple fiberwebs** are used to produce nonwovens from natural staple fibers (e.g., cotton) or from manufactured staple fibers (e.g., rayon).
  - **Wet laid process** - Web is produced by filtering the short fibers from an aqueous suspension onto a screen belt or perforated drum, similar to papermaking. This is one of the fastest and least expensive methods of manufacturing fabrics.
  - **Dry laid process** – Web is produced by carded or air laid methods. The carded process lays fibers along the fabric length or alternately along the length and width of the fabric (cross laid). Air laid process is used for random arrangement. Fiber orientation affects properties such as strength and drape.

- **Polymer** or **spunlaid** process makes webs directly from manufactured **filament** fibers. Integrated systems include fiber forming and web formation as part of the fabric manufacturing process. Spunbond and flash spun methods are used to produce polymer webs.
Bonding methods are divided into mechanical, thermal and chemical.

- **In mechanical bonding**, fibers are entangled or stitched to hold them in place and add strength. Examples:
  - **Needle punching** uses needles to entangle the staple fiberwebs; it is used to produce material for nonwoven carpets and material made of manufactured fibers resembling wool felts.
  - **Spun lacing** or **hydroentangling** uses water to entangle (typically dry laid) fibers; it produces soft fabrics with good drapeability.
  - **Stitch bonding** uses chain or tricot stitches to hold the fiberweb together; the fabrics are common in window shades and glove liners. Note: Stitch-bonded fabric is a composite nonwoven fabric. Therefore, it can be considered a bonded (multicomponent) fabric.
Nonwoven Fabrics - Bonding

- **In thermal bonding**, heat is used to fuse and bond fibers.
  - Two commonly used thermal bonding methods are:
    - Fusing polymer web fibers that are still in a semi-solid stage.
    - Fusing a web in certain areas or points.
  - Only thermoplastic fibers can be thermally bonded.
  - Sometimes sheath-core bicomponent fibers with a sheath made of polymer with a low melting point or binder fibers with a low melting point are used.

- **In chemical bonding**, resins or binders are used to bond the fibers.
  - The properties of the nonwoven fabric are affected by the chemical used for bonding.
  - Chemical choice depends on intended end use. For example, chemical bonding is typically suitable for most food packaging and personal hygiene products.
Multicomponent Fabrics

- Multicomponent fabrics consist of two or more fabrics or materials combined to form a new fabric.

- The performance of the new fabric is different from that of the individual fabrics and/or materials used to produce the multicomponent fabric.

- Multicomponent fabrics:
  - Quilted
  - Bonded
  - Laminated
  - Coated
Multicomponent Fabrics - Quilted

- **Quilted** fabrics are produced by stitching or fusing two or more layers of materials together, by hand or machine.

  - **Stitched with thread**, layers of material are held together and stitched by hand (as in traditional hand quilting) or by machine (on large flatbed quilting machines). The lines of stitching form geometric or other patterns.
In **threadless stitching**, layers are fused together at various points. The fused points appear as small dots or lines and form geometric or other patterns resembling quilted fabrics stitched with thread. This process is used for crib mattresses, mattress pads, and low-cost comforters.
• **Laminated fabrics** are produced by joining a layer of fabric with a layer of film or membrane, using a resin or adhesive.
  - Two-layer laminates (woven, knitted, or nonwoven) are laminated to an air-impermeable film or microporous membrane.
  - In three-layer laminates, a film or membrane is sandwiched between two fabrics or vice versa. GORE-TEX® and a few limited-use fabrics used for protective apparel are examples. The laminated layers can be pulled apart.

• **Bonded fabrics** are produced by joining two or more layers of fabric with a resin, foam, rubber, or adhesive.
Laminated Fabric - Microporous membrane laminated between two nonwoven layers.

Note: This multicomponent material is used to manufacture limited-use protective apparel.
Multicomponent Fabrics - Coated

- **Coated fabrics** are produced by coating fabric surfaces with a resin, rubber, or vinyl.

- The coating is applied to the fabric face or back depending on intended use.

- The durability of coated fabrics varies considerably depending on coating type, environment, and other conditions in use. Some coatings crack after extended use.

- Some coated fabrics may be damaged during sewing; holes created by stitching may widen during use as the fabric near the seam is pulled in different directions.
Open-mesh Fabrics

- **Open-mesh** lace, net, and macramé are produced using hand and machine processes. Open-mesh is not a fabric construction technique, but several techniques are used to create open-mesh fabrics.

- **Lace** is a decorative open-mesh fabric construction, originally produced by hand.
  - Europe is renowned for bobbin or pillow lace.

- Lace-making machines were invented to reduce time and cost; the Leavers machine produces lace similar to handmade bobbin lace.

- In the 20th century, producing lace and lace fabric on Raschel knitting machines drastically reduced the cost. Today, most low- to medium-priced lace is produced on Raschel knitting machines.
Examples of Open-mesh Fabrics

- tatted lace
- crochet lace
- handmade filet lace
- raschel knit lace
- weft knit lace
- tricot knit netting
Open-mesh Fabrics - Handmade Lace

- **Bobbin lace** is made by plaiting the thread around pins inserted on a pillow to create a design using two sets of threads at one time.

- **Needle** or **point lace** is made by using buttonhole stitches to create a very elaborate design.

- **Filet lace** is made by creating designs with a darning stitch on hand knotted mesh.

- **Battenburg lace** is handmade lace using woven tape to create designs. The looped, woven tape is stitched in place. Woven tapes make it easy to identify. It is used for many applications from trim on apparel to bedspreads.
Bobbin Lace (Pillow Lace) – Design on the paper used as a guide to create the design.

Note: Two pairs (sets of four) of bobbins are used make any stitch. On this slide a tape and pin are used to organize the bobbins in sets of four.

Courtesy Lacis Museum
Handmade Filet Lace – Darning stitch used to create the design on hand knotted mesh.
Open-mesh Fabrics - Handmade Lace

- **Knitted lace** is made with fine knitting needles, is faster to produce, and is not as intricate as bobbin or needlepoint lace.

- **Crochet lace** is made by forming loops with a crochet hook. Crochet has a variety of end uses including purses, shawls, scarves, and blankets (including baby blankets).

- **Tatted lace** is produced by knotting thread using a tatting shuttle or needle, and the lace is used for edgings, collars, and doilies.

Note: Machine made laces are often called by the same name as the handmade laces they imitate, and are often named for the towns where they originated (e.g., Battenburg, Alencon, Chantilly).
Tatting Shuttles and Lace Produced Using a Tatting Shuttle
The mechanization of lace making has undergone several changes. Most commercially available lace is produced on Schiffli embroidery and Raschel knitting machines.

- Complicated **Leavers lace machines** produce lace resembling bobbin lace by twisting the bobbin or weft threads around the beam or warp threads; it is very expensive with few companies still producing it.

- **Schiffli embroidery machines** produce lace by embroidering designs on fine, plain weave fabric, then chemically treating the embroidered fabric to dissolve the woven portions; this results in an open-mesh lace.

- **Raschel knitting machines** produce medium- and low-priced lace, including lace with a crochet-look made of yarns from heavy cottons to fine synthetics.
Lace Produced on a Weft Knitting Machine
Lace Made on a Leavers Lace Machine

Magnified view

face

back
Lace Produced on a Schiffli Embroidery Machine
Machine Lace – Chantilly imitation produced on a raschel knitting machine
Machine Lace – Raschel lace made with polyester yarns

Note: This is an example of an inexpensive machine lace. The cost of the 12”x9” lace is under two dollars.
Open-mesh Fabrics - Net

- **Net** can be produced by hand knotting or machine knitting and knotting methods.

- **Bobbinet tulle**, the original tulle produced on bobbinet machines, is produced by looping weft yarns diagonally around the warp yarns to create a hexagonal net (similar net was used for handmade bobbin or pillow lace).

- Today, **tulle** is produced on tricot knitting machines. The cost of production is considerably lower.
Tufted fabrics are produced by inserting loops in base fabrics using tufting machines with needles that create the pile.

- Yarns or strips of fabric form the loops or pile and can be cut or remain uncut.

- Tufting machines range from hand tufting machines to wide-width machines used for carpets.

- Pile height and density affect performance and cost of the fabric.

- The tufting method of fabric construction dominates the rug and carpet industry. Tufted fabric is either coated or backed to prevent the tufts from pulling out.

- Tufting produces pile fabrics for bedspreads, upholstery fabric, and bathrobes.
Tufting

8 Needle Tufting Machine

Source - Dictionary of Fiber and Textile Technology. Adapted with permission.
Braided fabrics are narrow-width fabrics produced by plaiting three or more yarns. They can be flat or circular.

Common end uses of flat braids include belts and decorative trim.

Common end uses of circular braids include decorative trims, area rugs, cords, wire insulation, handles for gift bags, and string.
Elasticized Decorative Braid – Monofilament spandex yarn covered with circular braid made of metallic yarns
Embroidered

- **Embroidery** is "ornamental design worked on a fabric with threads. Embroidery may be done either by hand or by machine" (Source - *Dictionary of Fibers and Textile Technology*).

- In many countries traditional hand embroidery techniques are still used for apparel, bags, bedspreads, cushion covers and other items.
Hand Embroidered Bags and Cushion Covers
Hand Embroidered Bedspread

Note: Chain stitch has been used to embroider a traditional design from Kashmir, India.
Embroidered

- Embroidery machines are used to duplicate hand embroidered designs while reducing production costs.

- Embroidery machines range from computerized home sewing machines to wide-width Schiiffli embroidery machines.
  - Multi-needle embroidery machines are used to embroider designs on baseball caps, shirts, bags, etc.
  - Multi-head embroidery machines are used to embroider fabrics.
  - Cutwork (including eyelet) is produced on a Schiiffli embroidery machine.
  - Beaded and sequined embroidery can be manufactured on several machines.
Computerized Single-head, Multi-needle Embroidery Machine
Multi-head Embroidery Machine
Eyelet Embroidery Being Produced on a Schiffli Embroidery Machine