Built to resist pulling forces

Collagen gives tissues mechanical support. High tensile strength means that a large pulling stress is needed to break the material; it does not mean the material is highly stretchy.

CROSS-LINKED MOLECULES SHARE THE LOAD



Covalent cross-links limit sliding between neighbouring molecules.

Schematic of part of a fibril: navy rods are collagen molecules, teal connectors are cross-links. Their positions and spacing are simplified.

1. STABILITY WITHIN EACH MOLECULE

Three polypeptide chains form a long triple helix. Interchain hydrogen bonds help stabilise this arrangement. The closely associated chains create a rope-like building block rather than a compact globular carrier.

2. STRENGTH ACROSS MANY MOLECULES

Molecules pack into fibrils, which group into fibres. Cross-links help transfer forces between molecules and resist their sliding apart. The assembled structure can therefore withstand tension better than an unlinked collection.

Distinguish the bonds: peptide bonds run along each chain; hydrogen bonds help stabilise the triple helix; covalent cross-links reinforce the assembly.

Supporting reading: Molecular Biology of the Cell: extracellular matrix.

Scope: Cambridge Biology 9700 syllabus, section 2.3, outcome 8, p. 18.

Match the arrangement to the job

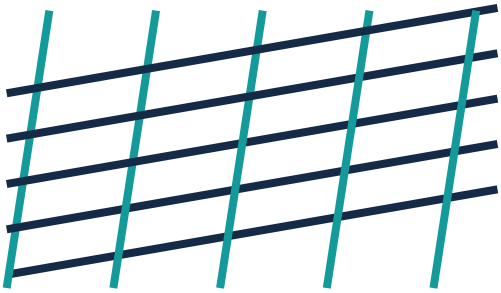
The same fibrous protein can contribute to different tissues. Fibre orientation and other matrix components help determine the mechanical behaviour of the whole tissue.

TENDON



Parallel bundles resist pulling mainly along the tendon's length.

SKIN DERMIS



Interwoven fibres resist pulling from several directions.

Simplified fibre arrangements, not drawings of individual molecules.

1. TENDONS AND LIGAMENTS

Tendons attach muscle to bone and transmit the force of contraction. Ligaments connect bones at joints and help limit excessive movement. Collagen supplies tensile strength; it does not actively contract.

2. BONE AND CARTILAGE

In bone, collagen provides a tough framework while mineral deposits add hardness and resistance to compression. In cartilage, collagen reinforces a hydrated matrix. Do not attribute every property of either tissue to collagen alone.

In skin and blood vessel walls, collagen helps prevent overextension and tearing. Other components, including elastic fibres, contribute to stretch and recoil.

Supporting reading: OpenStax Anatomy and Physiology 2e, section 4.3.

Scope: Cambridge Biology 9700 syllabus, section 2.3, outcome 8, p. 18.

Explain the feature and its effect

A useful explanation goes beyond naming collagen. Link a structural feature to a mechanical property, then connect that property to a tissue's role.

FEATURE	WHY IT HELPS
Long, triple-helical molecules	Rope-like units form an extended supporting material.
Many molecules in fibres	The assembly distributes pulling forces across many units.
Cross-links between molecules	Reduce sliding and reinforce resistance to tensile failure.
Insoluble assembled fibres	Remain as a stable framework in the watery tissue environment.

STRENGTH IS NOT THE SAME AS ELASTICITY

Tensile strength concerns resistance to breaking under tension. Extensibility concerns how much a material lengthens; elasticity concerns recovery after deformation. Collagen mainly supplies tensile reinforcement. Elastin is especially important for large, reversible stretch.

PUT THE LINKS TOGETHER

A tendon must transmit a muscle's pull to a bone. Its collagen-rich, aligned fibre bundles provide tensile strength, while cross-links reinforce the molecular assembly. This lets the tendon carry force without easily pulling apart.

Avoid absolutes: collagen-rich tissues can bend and show some stretch. "Strong" does not mean perfectly rigid, impossible to extend, or impossible to break.

Supporting reading: RCSB PDB-101: Collagen.

Scope: Cambridge Biology 9700 syllabus, section 2.3, outcome 8, p. 18.