

Biochemical composition of synovial fluid and cartilage

Synovial fluid is a thick fluid found in cavities of synovial joints. With its yolk like consistency, synovial fluid reduces friction between the articular cartilage and other tissues in joints to lubricate them during movement. The vascular synovial membrane secretes the synovial fluid into the joint cavity. This fluid forms a thin layer at the surface of the cartilage and also sweeps into microcavities and irregularities in the articular cartilage surface filling all empty spaces. The fluid in articular cartilage serves as a synovial fluid reservoir. During movement, the synovial fluid held in the cartilage is squeezed out mechanically to maintain a layer on the cartilage surface.

I - Synovial fluid composition:

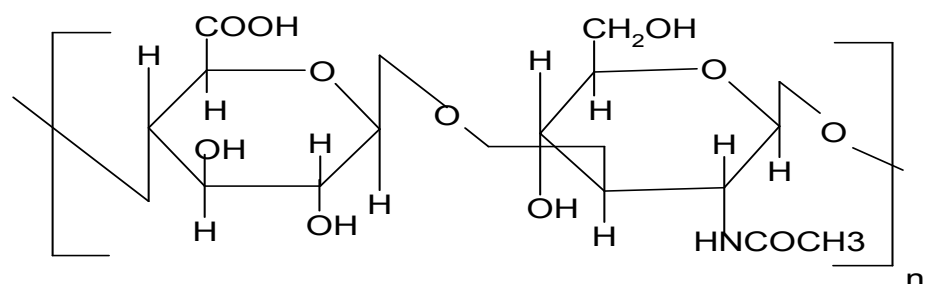
The major components of synovial fluid are hyaluronic acid, lubricin, proteinases and collagenases which are present in fluid filtrated from plasma. It is highly viscous, clear, colourless fluid with few white blood cells.

Hyaluronic acid (Hyaluronan):-

It is an acidic heteropolysaccharide or glycosaminglycan (GAG). In normal synovial fluid hyaluronic acid concentration is about 3-4 mg/ml. It is a linear polymer of repeating disaccharide units of glucuronic acid and N-acetyl D glucosamine linked by β 1,3 glycosidic bonds. The unit is attached to the next by β 1,4 linkages. It acts as a lubricant and shock absorber. It is also present in loose connective tissues.

Hydrolytic products of hyaluronic acid:

- D-glucuronic.
- D-glucosamine
- Acetic acid.



Hyaluronic acid

Lubricin:

is a glycoprotein help in lubrication and control synovial cell growth.

Glycoproteins

- Glycoproteins are proteins that have oligosaccharides chain (one or several) attached covalently to the polypeptide backbone. The carbohydrate moieties are smaller and more structurally diverse than the glycosaminoglycans of proteoglycans.
- The carbohydrate units may be O – linked (sugar is attached by a glycosidic link to the – OH of serine or threonine) or N – linked (sugar attached to the – NH₂ group of asparagines).
- Carbohydrate may constitute from 1 – 70% of glycoproteins.
- The sugar unit in glycoprotein is:
 1. N-acetyl amino sugar (N-acetyl glucosamine or N-acetyl galactosamine).
 2. Hexoses (mannose and galactose).
 3. L-fucose (6-deoxy-L-galactose)
 4. Sialic acid.(N-acetyl derivatives of neuraminic acid)

N.B: Other examples and functions of glycoproteins:

1. Structural or adhesion glycoproteins as laminin and fibronectin.
2. Lubricant and anti-enzyme as mucin.
3. Cell attachment and recognition site.
4. Some hormones, immunoglobulins and enzymes (proteases) are glycoproteins.
5. Some structural proteins as collagen, elastin and fibrin are glycoproteins.

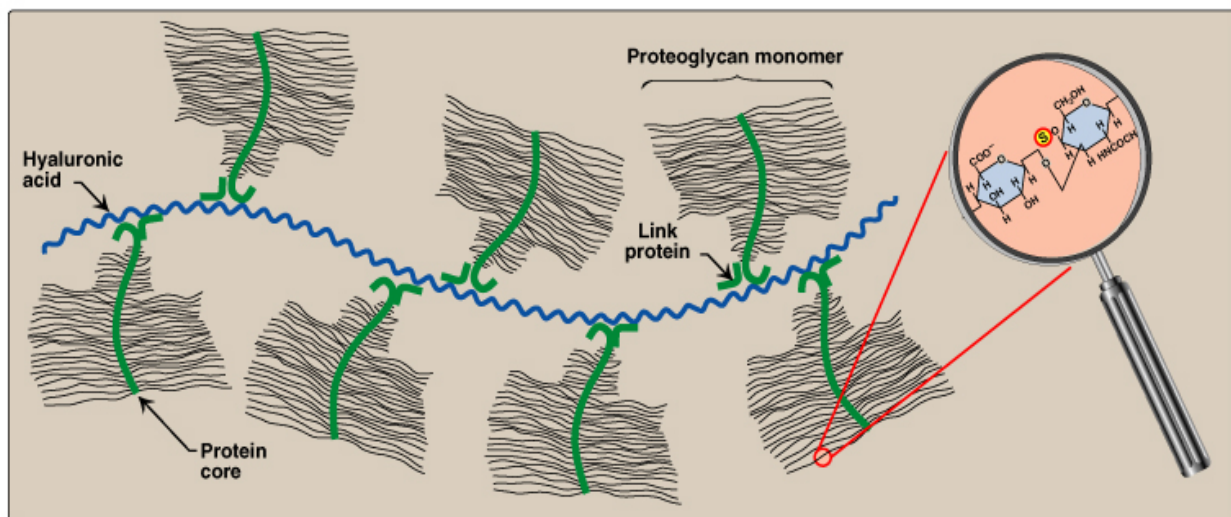
II- Composition of cartilage:

Cartilage is avascular structure receives nutrients via synovial fluid. Cells (chondrocytes) form less than 5% of tissue volume. The rest of the cartilage is organic extracellular matrix. The major components of this matrix are water, proteoglycans and collagen .Water permits movement of gases, nutrients waste products between chondrocytes and synovial fluid.

Proteoglycans:

These are macromolecules found in extracellular matrix or cell surface containing up to 95% carbohydrates. The basic proteoglycan unit is called (Aggrecan or proteoglycan monomer) consists of core protein with covalently attached GAGs. The aggregation of these proteoglycan monomers promotes immobilization of proteoglycans within the collagen mesh work, adding structural rigidity to the matrix.

Proteoglycans contain a long strand of hyaluronic acid to which link proteins are attached non-covalently. In turn link proteins interact non-covalently with core protein molecules. However glycosaminoglycans are attached covalently to core protein by glycosidic bonds between sugar residue and OH of serine.



The GAGs attached to the core protein are:

1. Chondroitin Sulphate:

Chemistry: It consists of a polymer of disaccharide units of D-glucuronic acid and N-acetyl-D-galactosamine sulphated at either its carbon 4 or 6. Intraunit the linkage is $\beta 1 \rightarrow 3$, while it is $\beta 1 \rightarrow 4$ inter the units.

Distribution: Bone and Cartilage.

Hydrolytic products:

- D-glucuronic acid.
- D-galactosamine
- Acetic acid.
- Sulphuric acid.

2. Keratan sulphate

It is a polymer of disaccharide units of D-galactose + N- acetyl D-glucosamine (no uronic acid). Sulphate may be present on C6 of either sugar. It is present in cornea and loose connective tissue.

3. Heparan sulphate

.It is formed of repeating disaccharides units of D-glucosamine 2,6 disulphate and either of 2 uronic acids [D-glucuronic acid 2-sulphate and L-iduronic acid 2-sulphate] in α 1-4 linkage. In between units the linkages are also α 1-4 glycosidic linkages. L-iduronic acid forms 90% of the uronic acid present and the rest is in the D-glucuronic acid form .L-iduronic acid is the 5-epimer of glucuronic acid.

4. Dermatan sulphate

The repeating disaccharide unit contains L-iduronic acid mainly with variable amounts of D-gulcuronic acid + N-acetyl D-galactosamine-4-sulphate. It is present in blood vessels, heart valves and skin.

Chondroitin sulfate is the major GAG in cartilage. The high number of negative charges on GAGs, gives it high affinity to water, so hydrate the entire tissue. This protects against high levels of stress and strain when the cartilage exposed to load. Proteoglycans are not only components of extracellular matrix where they are associated with each other and with major structural components of the matrix (collagen or elastin). Certain proteoglycans are associated with plasma cell membranes and as receptors.