

In **mammals**, there are 21 variants of **amino acids AA**, the building blocks for **proteins**.

12 **AAs** are prescribed by DNA and produced on demand. All **AAs** are available in food.

In the chart below, **↑** indicates **AA** we cannot produce; we must get from food: these 9 **essential AAs** !

In **biochemistry** and **molecular biology**, a **residue** refers to a specific **monomer** within the **polymeric chain** of a **polysaccharide**, **protein** or **nucleic acid**. (preferring **monomer**: the **AA** core depicted above, or:  $\text{NH}_2\text{-CHR-COOH}$ )

The core **monomer AA base unit** pictured above allows for variant "add-ons" replacing the variable **R**.

The simplest **AA** is **glycine** in which **R** is simply the **Hydrogen** atom. **Glycine is the predominant AA in fiber**.

The chart below depicts variants of **R**, indicating 5 have valence:  $3+ / 2-$  ; 16 have no valence (neutral).

**Proline**, 2<sup>nd</sup> and hydroxyProline, 4<sup>th</sup> predominant, feature the pyrrole ring with zwitterion (labile electron).

Methionine & **cysteine** sisters have **Sulfur** atoms - having only .7% occurrence in collagen; more in keratin.

During production by fibroblast cells, **AA** building blocks are linked end-end into peptides (sub-proteins), and finally completed for **proteins**. Depending on the sequence, in fact - **determined by the sequence**, of **AA** variants comprising the protein chain, the result is a **3-dimensional molecule** with functional **conformation**.

**Shape** is functionally important in the biological and/or biochemical role served by each protein.

Generally, the human is a concerted cluster of functional colonies of cells, including organs and **structural** elements, all bounded by the skin (epidermis) - separating **inside** from outside.

The food tube enables selective nutritional uptake - from outside within tube >> into the **inside**.

**Structural** proteins in the human account for **1/3** of total **body mass**.

Three main types generally referred to as **collagen** have distinct roles:

1. micro - cell membrane and internal cellular matrix or "skeleton".
2. macro - membranes in the form of **β-sheet**: e.g. enveloping organs.
3. macro - **fibers** - arranged in the simplest of protein conformations, **linear** - each chain aligning parallel and contiguous / attached with other duplicates - linked into triple helical chain spiraling around a central, virtual, linear, uni-directional axis.

A special case is the most stable **α-helix**, the basis for the toughest bio-armor in forms of **α-keratin**, produced by keratinocytes near the **outside**: e.g.: hair, horns, nails and cornea.

Rigidity is increased by di-Sulfide bonds with cysteine **AAs**.

Slightly less compact (allowing for the pyrrole rings of proline), with only .1% cysteine,

otherwise equally linear and uniform is the **collagen helix**, illustrated, the triple-helix basis of **fiber**

comprising **ligament** and **tendon** which tie into **bone**. Tendons transition from bone to spreading

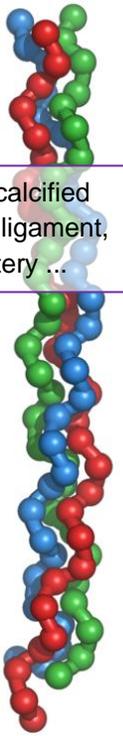
fibers morphing into **β-sheet** formation which merges into the fascia integrating into myofascial

envelopes of muscle cells - membranes enclosing muscle fibers: myofilaments comprising

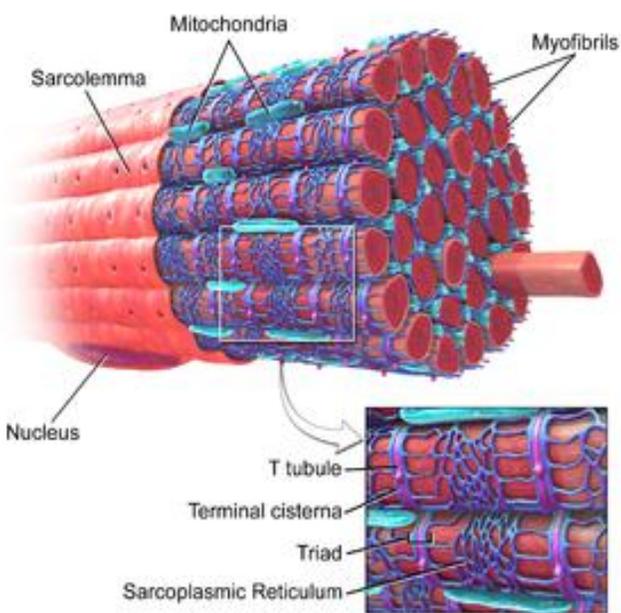
**myofibrils** - within muscle cells. (below)

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atomic view of fibril - the non-calcified flexible structural element of: ligament, tendon, fascia, membrane, artery ...

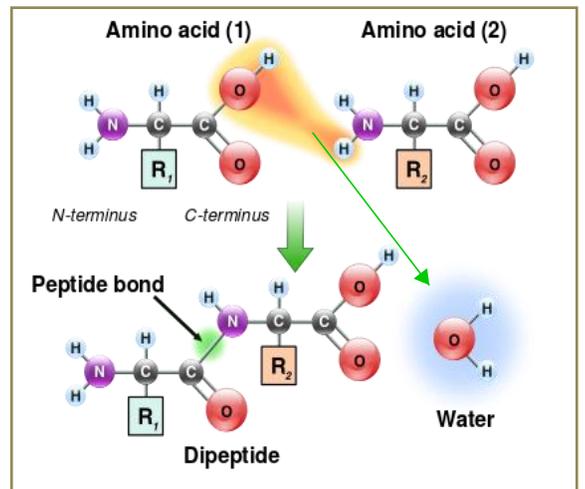
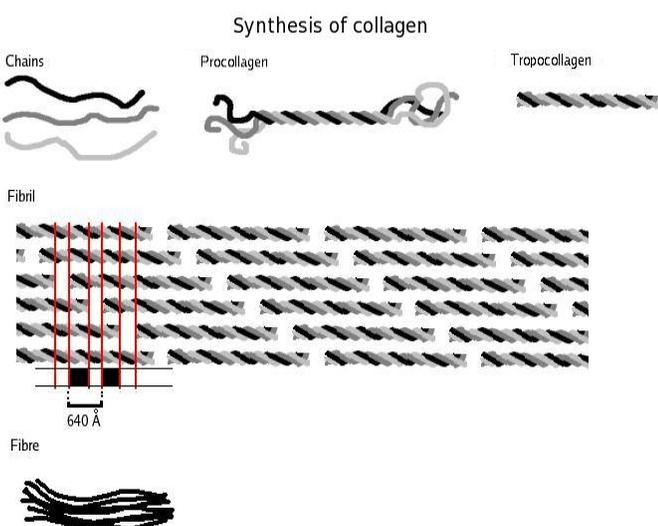


Skeletal Muscle Fiber



<http://en.wikipedia.org/wiki/Sarcolemma>

The **sarcolemma** is the cell membrane enveloping the striated skeletal muscle cell providing broad membranous merging attachment to the dense linear fibers of the tendon.



[http://en.wikipedia.org/wiki/Amino\\_acid](http://en.wikipedia.org/wiki/Amino_acid)

**Twenty-One Amino Acids**

⊕ Positive ⊖ Negative  
\* Side chain charge at physiological pH 7.4

**A. Amino Acids with Electrically Charged Side Chains**

| Positive                             |                                     |                                      | Negative                            |                                     |
|--------------------------------------|-------------------------------------|--------------------------------------|-------------------------------------|-------------------------------------|
| Arginine (Arg) <b>R</b>              | Histidine (His) <b>H</b>            | Lysine (Lys) <b>K</b>                | Aspartic Acid (Asp) <b>D</b>        | Glutamic Acid (Glu) <b>E</b>        |
| pkKa 2.03<br>pkKa 9.00<br>pkKa 12.10 | pkKa 1.70<br>pkKa 9.09<br>pkKa 5.94 | pkKa 2.15<br>pkKa 9.16<br>pkKa 10.67 | pkKa 1.95<br>pkKa 9.69<br>pkKa 3.71 | pkKa 2.16<br>pkKa 9.35<br>pkKa 4.15 |

**B. Amino Acids with Polar Uncharged Side Chains**

|                        |                          |                                     |                                     |
|------------------------|--------------------------|-------------------------------------|-------------------------------------|
| Serine (Ser) <b>S</b>  | Threonine (Thr) <b>T</b> | Asparagine (Asn) <b>N</b>           | Glutamine (Gln) <b>Q</b>            |
| pkKa 2.13<br>pkKa 9.05 | pkKa 2.20<br>pkKa 9.10   | pkKa 2.16<br>pkKa 9.10<br>pkKa 9.40 | pkKa 2.18<br>pkKa 9.10<br>pkKa 9.40 |

**C. Special Cases**

|                                      |                               |                        |                         |
|--------------------------------------|-------------------------------|------------------------|-------------------------|
| Cysteine (Cys) <b>C</b>              | Selenocysteine (Sec) <b>U</b> | Glycine (Gly) <b>G</b> | Proline (Pro) <b>P</b>  |
| pkKa 1.91<br>pkKa 10.28<br>pkKa 8.14 | pkKa 1.9                      | pkKa 2.34<br>pkKa 9.58 | pkKa 1.95<br>pkKa 10.47 |

**D. Amino Acids with Hydrophobic Side Chain**

|                        |                        |                           |                        |                           |                              |                         |                           |
|------------------------|------------------------|---------------------------|------------------------|---------------------------|------------------------------|-------------------------|---------------------------|
| Alanine (Ala) <b>A</b> | Valine (Val) <b>V</b>  | Isoleucine (Ile) <b>I</b> | Leucine (Leu) <b>L</b> | Methionine (Met) <b>M</b> | Phenylalanine (Phe) <b>F</b> | Tyrosine (Tyr) <b>Y</b> | Tryptophan (Trp) <b>W</b> |
| pkKa 2.33<br>pkKa 9.71 | pkKa 2.27<br>pkKa 9.72 | pkKa 2.26<br>pkKa 9.40    | pkKa 2.32<br>pkKa 9.58 | pkKa 2.19<br>pkKa 9.09    | pkKa 1.91<br>pkKa 9.29       | pkKa 2.18<br>pkKa 9.24  | pkKa 2.35<br>pkKa 9.34    |

↑ must eat; cannot internally produce.