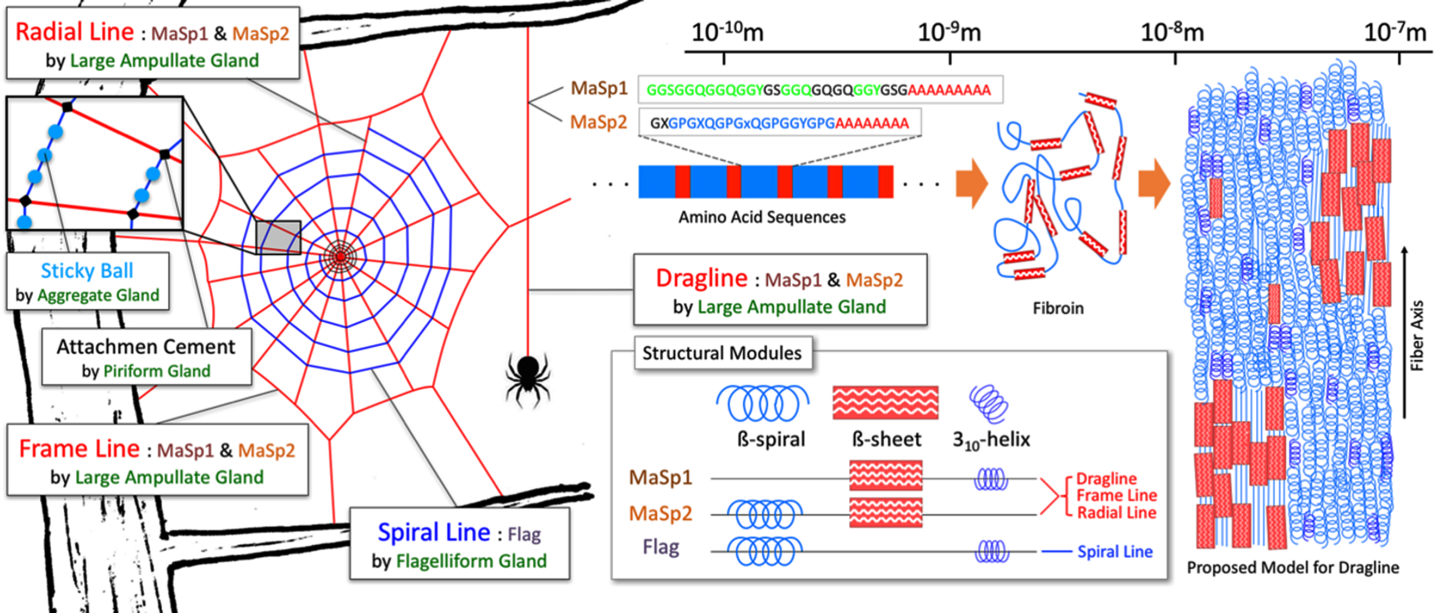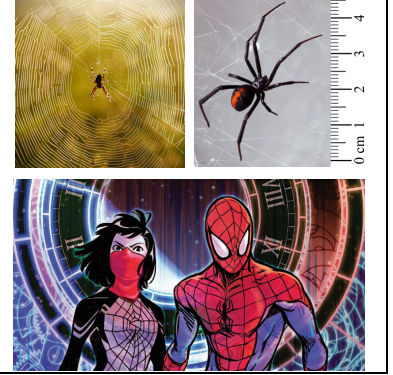# 🕷 Spider silk & webs 🕸

SIZE AND STRENGTH

- Spider silk is a protein fiber that has a diameter of ~3 μm $\left(\dfrac{1}{333}\,\text{mm}\right)$

  $\Rightarrow \dfrac{1}{10}$ th the size of human hair!
- Spider dragline silk has a tensile strength (T.S.) of ~1.3 Gpa
  $\Rightarrow$ ~5 times stronger than some types of steel! (by equal weight)
- Darwin's bark spider may have the world's strongest silk (~1.65 GPa)
 $\Rightarrow$ Tungsten (Earth's strongest natural metal) has a T.S. of 1.51 Gpa

Radial Line : MaSp1 & MaSp2
by Large Ampullate Gland

Sticky Ball
by Aggregate Gland

Attachmen Cement
by Piriform Gland

Frame Line : MaSp1 & MaSp2
by Large Ampullate Gland

Spiral Line : Flag
by Flagelliform Gland

MaSp1 GGSGGQGGQGGYGSGGQGQGQGGYGSGAAAAAAAAA
MaSp2 GXGPGXQGPGxQGPGGYGPGAAAAAAAAA

Amino Acid Sequences

Fibroin

Dragline : MaSp1 & MaSp2
by Large Ampullate Gland

Structural Modules

	ß-spiral	ß-sheet	3₁₀-helix	
MaSp1				Dragline / Frame Line / Radial Line
MaSp2				
Flag				Spiral Line

Proposed Model for Dragline

Fiber Axis

10^{-10}m 10^{-9}m 10^{-8}m 10^{-7}m

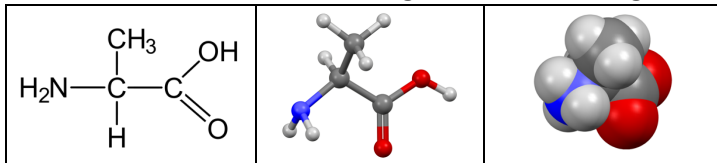## CHEMISTRY – Atoms ⚛ & Amino Acids

Amino acids are molecules. The key atoms within them are:
carbon (C), **hydrogen** (H), **oxygen** (O), & **nitrogen** (N).

Glycine, alanine, & serine are among the main
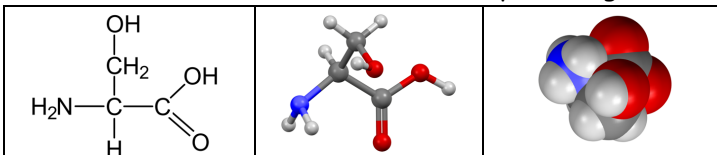amino acids (AA) that make up spider silk proteins.

Glycine: $C_2H_5NO_2$ (Gly or G)* $\Rightarrow$ gives silk its elasticity
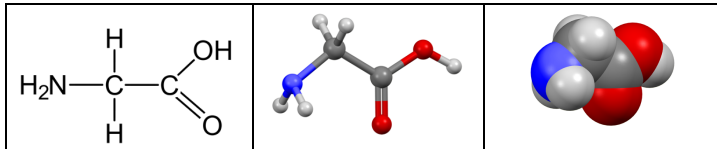
Alanine: $C_3H_7NO_2$ (Ala or A) $\Rightarrow$ gives silk its strength

Serine: $C_3H_7NO_3$ (Ser or S) $\Rightarrow$ forms 'spacer regions'

⚛ colors: (C) = grey, (H) = white, (O) = red, (N) = blue


BIOCHEMISTRY – AAs & Proteins 🔬🧪🧬

- **Atoms** are the 'building blocks' of **molecules**.
- **Amino acid molecules** are the 'building blocks' of **proteins**.
- **Proteins** are the 'building blocks' of spider **silk, cells**, etc.
  $\Rightarrow$ Proteins are large molecules made of long AA chains.

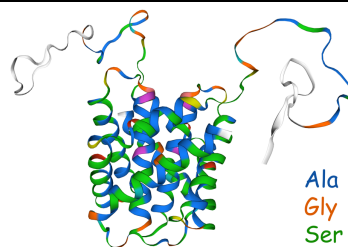**Spidroin** & **Fibroin** are among the main proteins in 🕷 silk.

Dragline silk fiber is made up of two types of **Spidroins**:
- MaSp 1 & 2 (major ampullate silk protein 1 & 2)
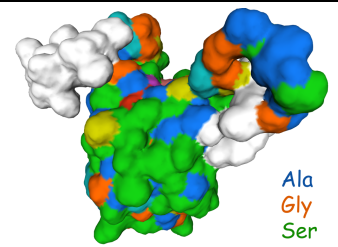 $\Rightarrow$ MaSps contain around 3500 amino acids

**Fibroin's** primary structure (a chain of amino acids that repeats n times)

Gly   Ser   Gly   Ala   Gly   Ala
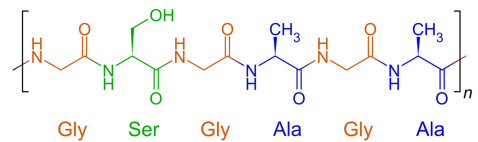
Fibroin-3 (European garden spider) | **Fibroin-3** (European garden spider)

Ala
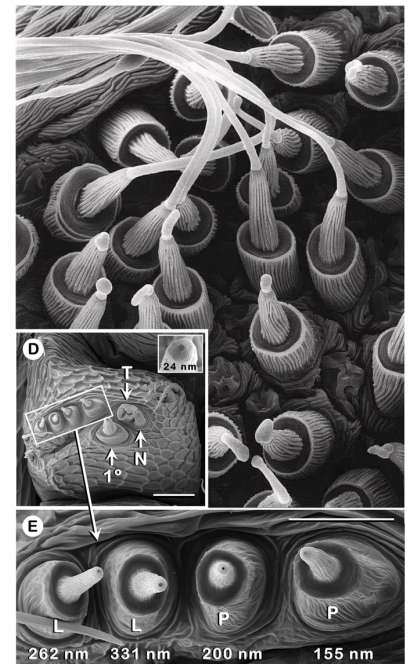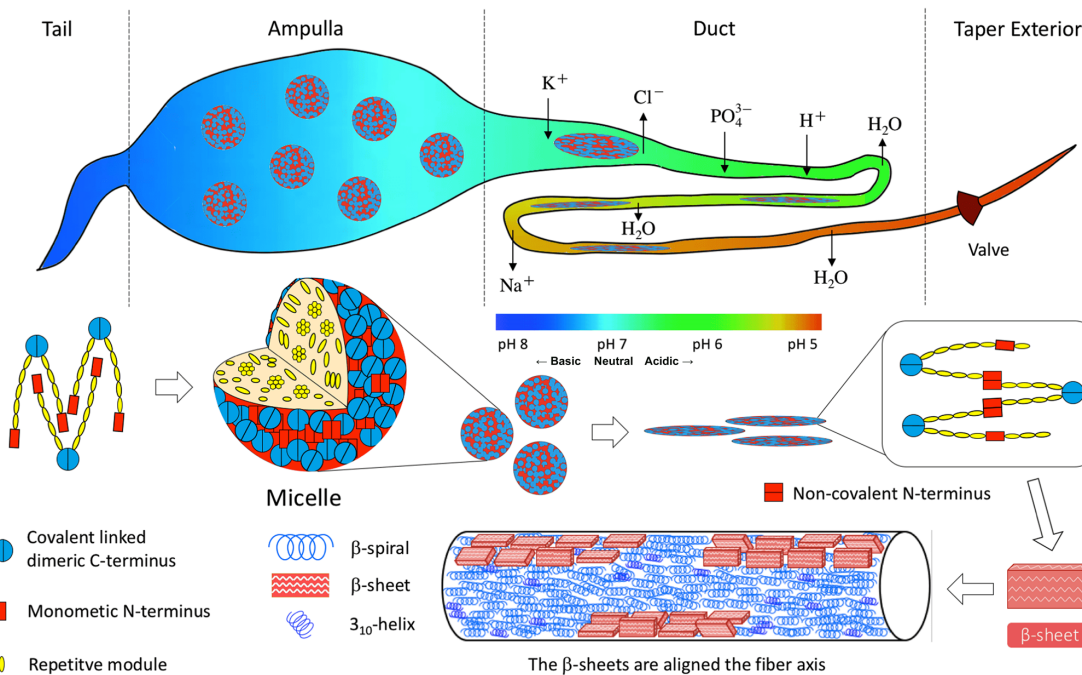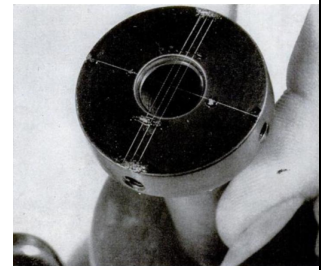Gly
Ser

TYPES & USES OF SPIDER SILK 🕷

Multiple silk glands secrete different proteins that are pushed through spigots on the spider's spinnerets to make multiple types of silk for a variety of purposes, including:

- making their webs (sticky & non-sticky)
- entombing their prey
- floating & gliding in the air
- providing an alternative source of food
- making cocoons to protect their eggs
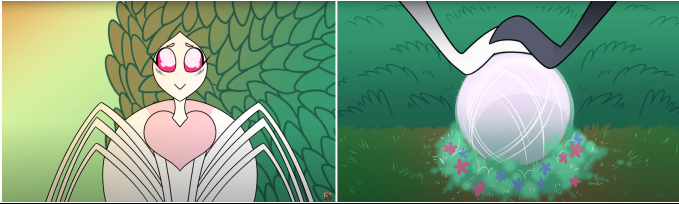
HUMAN USES OF SPIDER SILK 🕸

- Crosshairs in telescopes, microscopes etc. (Black widow spider)
- Violin strings
- Artificial human skin
- Nuclear fusion reactors
- Cloth - from Golden orb spider, Madagascar 🇲🇬

Tail   Ampulla   Duct   Taper Exterior

K^+ Cl^- PO_4^{3-} H^+ H_2O

H_2O

Na^+ H_2O

Valve

pH 8   pH 7   pH 6   pH 5
← Basic   Neutral   Acidic →

Micelle

Non-covalent N-terminus

- 🔵 Covalent linked dimeric C-terminus
- 🟥 Monometic N-terminus
- 🟡 Repetitve module

- 〰 β-spiral
- 🟥 β-sheet
- 🌀 3_{10}-helix

β-sheet

The β-sheets are aligned the fiber axis

D   T   24 nm
N
1°

E
L   L   P   P
262 nm   331 nm   200 nm   155 nm

UNITS 📏 ⚖

1 centimeter (cm) = $\frac{1}{100}$ m   = 10^{-2} m

1 millimeter (mm) = $\frac{1}{1,000}$ m   = 10^{-3} m

1 micrometer (µm) = $\frac{1}{1,000,000}$ m   = 10^{-6} m

1 nanometer (nm) = $\frac{1}{1,000,000,000}$ m   = 10^{-9} m

1 GigaPascal (GPa) = 1,000,000,000 Pa   = 10^9 Pa

REFERENCES 🔍 📚 🌍 🌍 🌍

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* Skeletal formula of neutral glycine, ...