PROLINE MODULATES INTERACTIONS BETWEEN CHARGED SURFACES: UNDERSTANDING SALT TOLERANCE IN PLANTS

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1. THE PROBLEM: INCREASING SALINISATION OF AGRICULTURAL SOILS

The UN has reported that between **20 to 50 per cent** of irrigated soils in all continents have become **too salty** to be fully fertile for agriculture.

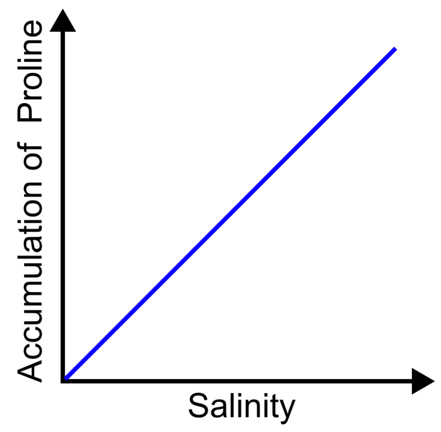
This creates significant challenges for more than **1.5 billion people** who need access to this soil to grow their food, mostly in **developing regions** of the world.

Soil salinisation is being increasingly caused by **human activity**, due to **mismanagement**, excessive use of **fertilisers**, **deforestation** and **rising sea levels**.

To meet the UN Sustainable Development Goal (SDG2) to **"end hunger, achieve food security, and promote sustainable agriculture"**, alternative agricultural strategies must be developed.

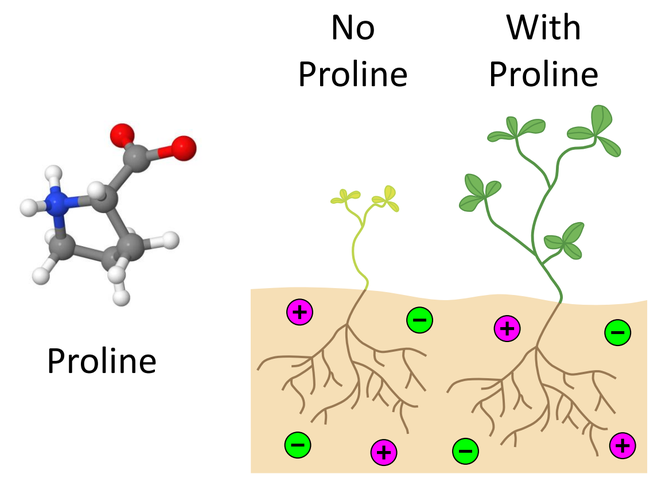
2. THE SOLUTION: CAN WE LOOK TO NATURE FOR ANSWERS?

Halophytes (salt-loving plants)
E.g. sea thrift



The accumulation of the amino acid, **proline**, is correlated with the salinity of the growth environment of **halophytes**.

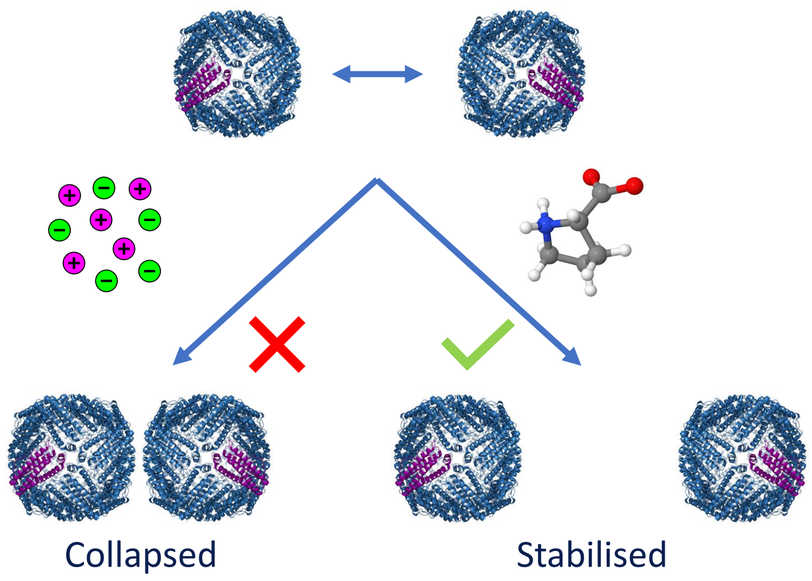
The addition of proline to the surrounding soil has been found to **enhance plant growth** in high salt-conditions.



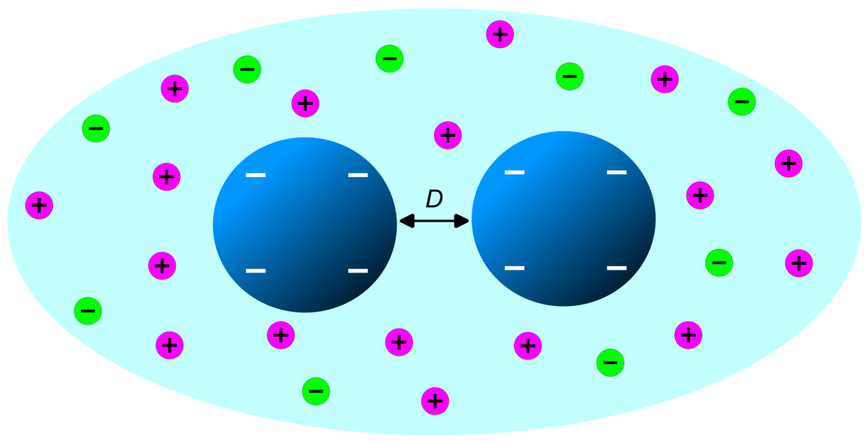
The application of proline to soils could **enhance productivity of crop growth** in salt-stressed environments.

3. WHAT IS THE UNDERLYING CHEMISTRY?

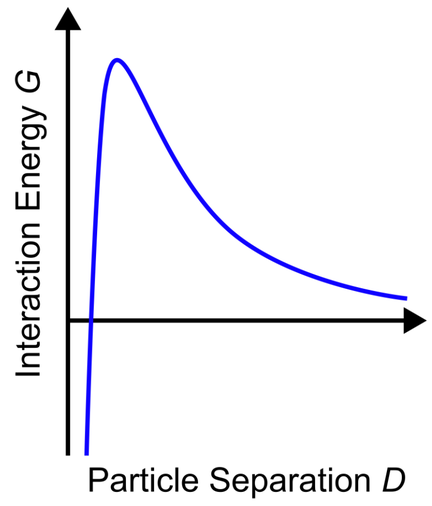
Why is biochemical function **compatible** with the **accumulation of proline**, but **not of salt**?
For example, what is preventing the **collapse of proteins** that occurs in salt-containing solutions?



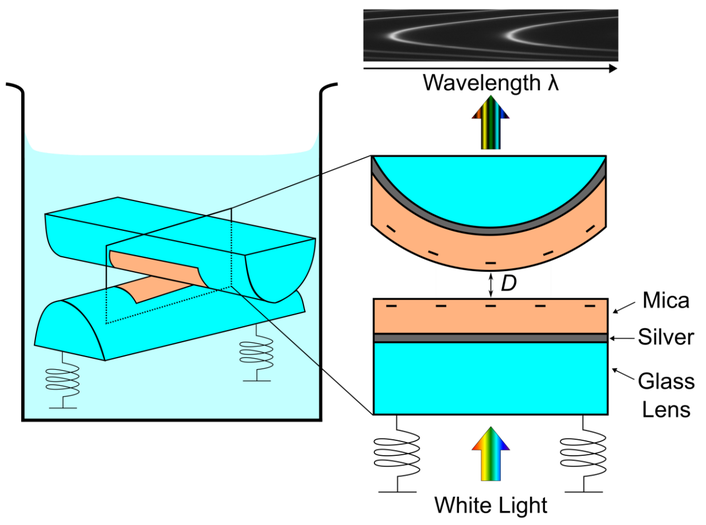
By treating biological molecules, including proteins, as **charged** "**colloidal**" particles, we can use techniques from physical chemistry to investigate how such particles interact in liquids containing different **types** and **concentrations** of **dissolved substances**.



These techniques can be used to determine the **interaction energy** between two particles as their **separation** is varied.



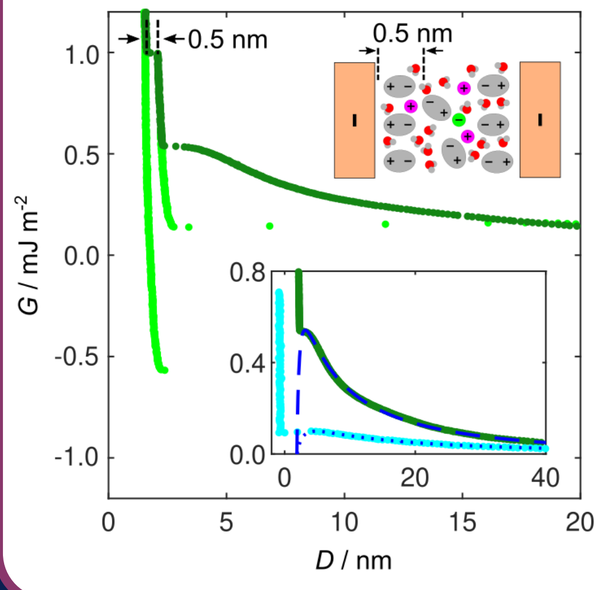
4. OUR APPROACH: THE SURFACE FORCE BALANCE



The **surface force balance** (SFB) allows us to measure the interaction energy between particles at separation distances down to the **nanoscale**.

This allows us to **directly observe** interactions between the surfaces at the **molecular level**.

5. OUR RESULTS



Our measurements yield a **novel insight** into the **multifaceted** behaviour of proline at charged surfaces.

We observe that proline can assemble into **layers** at the surfaces. It also acts to enhance the magnitude of the **longer-range repulsion** relative to pure water.

These results illustrate a potential **molecular mechanism** for **proline-enhanced biochemical stability,** with implications for the development of salt-tolerant crops.

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References: [1] UN News – Global perspective Human stories. https://news.un.org/en/story/2021/10/1103532. Accessed Feb 2024. [2] el Moukhtari, A., Cabassa-Hourton, C., Farissi, M., & Savouré, A. *Frontiers in Plant Science*, *11*, 1127 (**2020**).