Guardians of flavonoid transport: deciphering the selectivity of ABCG transporters in plant growth and defense physiology using molecular simulation methods – How do plants choose which molecules to let through their "gates"?

Project Goal

Plants, like humans, must transport various substances across their cell membranes – both into and out of cells. This transport is handled by special proteins called transporters, which act like "intelligent gates" – they allow only specific molecules to pass through while blocking others. Our project focuses on two very similar transport proteins – ABCG61 and ABCG46 – which, despite 78% similarity in structure, perform completely different functions in plant life.

Research Description

What are we doing? Using advanced computer simulations, we study exactly how these proteins "recognize" and transport their molecules. ABCG61 helps plants cooperate with beneficial bacteria, while ABCG46 protects plants against pathogens and pests.

How are we doing it?

1. **3D Modeling**: We create detailed computer models of both proteins at different stages of transport to observe how their shape is changing. It's like taking a series of photos of a person in motion to understand how they move
2. **Molecule tracking**: We simulate the journey of various molecules through "tunnels" in the proteins – from entry to exit
3. **Identifying "filters":** We search for key protein fragments that decide which molecule passes through and which gets blocked
4. **Mechanism comparison**: We analyze differences between ABCG61 and ABCG46 to understand why such similar proteins have different functions

What do we expect? The main goal is to find key locations – specific amino acids (individual "building blocks" from which the protein is built) – that act as "molecular switches" and decide whether a given molecule will be allowed through or blocked (**Figure 1**). Next, we want to compare these key positions between ABCG61 and ABCG46 to check:

- Which amino acids are responsible for recognizing different molecules?
- Will swapping amino acids between proteins cause their transport functions to switch?
- Can we "reprogram" ABCG61 to transport ABCG46 substrates and vice versa?

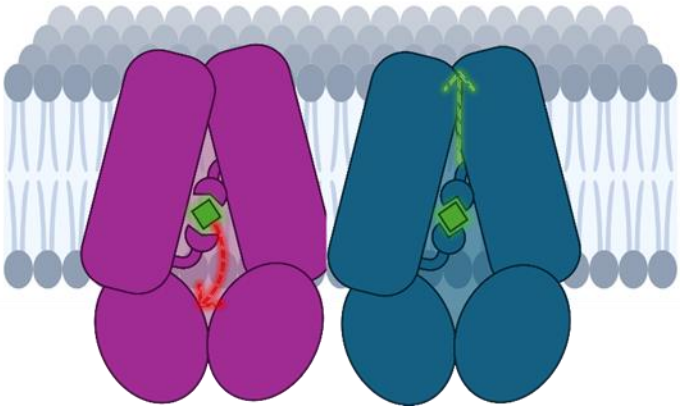

Figure 1 *ABCG transport proteins as "intelligent gates". Left protein blocks molecular transport, right protein facilitates passage. Differences in binding pocket shapes determine transport selectivity.*

Reasons for addressing the subject - why is it important?

Molecular transport across cell membranes is one of the most important processes in biology, but the mechanisms of selectivity remain poorly understood. Plants have an exceptionally large number of ABCG family transport proteins, indicating their crucial role in adaptation to terrestrial life. Thanks to new protein structure prediction methods (AlphaFold3), we can finally study these previously inaccessible structures in detail.

Practical Applications:

- **Sustainable agriculture**: The ability to modify plants so they better protect themselves against pathogens or more efficiently cooperate with beneficial bacteria – meaning reduced use of pesticides and synthetic fertilizers
- **Broader scientific context:** Understanding the mechanisms of plant transporters may contribute to understanding similar processes in humans, particularly in the context of drug resistance in medicine. The project may also open the way to designing proteins with desired transport properties in biotechnology.