

What's the point of probing the cell's mRNA stockroom?

Plant cells make thousands of mRNA copies that ferry genetic instructions from the nucleus to the cytoplasm, where proteins are built. Until recently, scientists thought this export was swift and barely regulated. We now know that cells can hold back fully processed mRNAs or pre-mRNA in the nucleus, creating a “safety buffer”. When a sudden demand for proteins arises – during development or under stress – these dormant molecules are released in bulk and reach ribosomes within minutes.

A slow-motion laboratory

The finest natural system for studying this buffering is the microsporocyte of the European larch. Its meiosis lasts five months, turning cellular events into a slow-motion movie. Researchers can harvest perfectly synchronized cell batches at every stage and follow individual RNA molecules with unrivalled precision.

Enter the Cajal body

Up to 41 % of nuclear mRNA accumulates inside Cajal bodies – tiny, membrane-less RNA-protein droplets. Our project will uncover which “postal codes” on an mRNA send it to a Cajal body, which protein “gatekeepers” lock it inside, and how the condensate's physical state changes over time. The central question: does warehouse-stored mRNA really hit ribosomes faster than continuously exported transcripts?

How will we do it?

- **Single-molecule transcriptomics** – direct Nanopore sequencing and 100-plex MERFISH will list every retained transcript.
- **RNA-protein interactome** – iCLIP and high-resolution DIA-PASEF proteomics will reveal at least 15 gatekeeper proteins.
- **Condensate physics** – super-resolution STED-Timebow imaging plus FRAP will measure viscosity and “export windows” of Cajal bodies.
- **Function in action** – real-time SunTag tagging of nascent peptides will test whether released mRNAs grant a head-start in translation.

Expected impact

We will deliver the first roadmap of mRNA warehousing in plants: retention signal motifs, a gatekeeper protein network and the physical constants of the condensate. All data and protocols will be released in the *RetainPlant v1.0* repository, paving the way for crops engineered to unleash emergency transcript reserves when drought or cold strikes. Ultimately, the study will illuminate how plants match protein production to abrupt environmental changes – from single molecules to whole-plant resilience.