Import of proteins into chloroplasts is differentially regulated by age

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New research has found that the transport of proteins into chloroplasts in plants is differentially regulated by the age of the chloroplast; upturning the previously accepted notion that this process is age-independent or only globally up- or down- regulated for all proteins. The research, led by Dr. Hsou-min Li, a Research Fellow from the Institute of Molecular Biology, Academia Sinica of Taiwan, is published October 30 in the open access journal *PLOS Biology*.

It's long been known that gene expression changes with age, for example, some genes are expressed in young organisms, others in aged organisms. However, up until now, it has been generally believed that the protein-transport processes that take place inside a cell occur independently of the cell's age.

Dr. Li and colleagues investigated pea leaves of different ages and discovered that proteins imported into chloroplasts—the organelles in plant cells where photosynthesis occurs—can be divided into three groups: one group prefers to be imported into very young chloroplasts, the second group has no special preference, and the third group prefer to be imported into older chloroplasts.

"Age-dependent regulation at the protein transport level had not been thoroughly investigated due to technical difficulties," Dr Li explained. "Pea seedlings offer an excellent model for such studies because each plant has leaves of different ages on a single stem and they are cheap to grow. Other scientists have taken advantage of this but at that time, they

only had a very limited number of proteins to test. Now with data from genomic and proteomic analyses, we can test a lot more proteins and can show not only that the regulation exists, but also that every protein can be regulated differently."

After finding this novel regulation, Dr Li's group then attempted to find the signal that controls age selectivity. They found that, for each protein, the age-selective signal is located within the signal peptide that controls organelle import. They also identified a signal-peptide motif that is necessary for targeting proteins to older chloroplasts.

"We knew that signal peptides specify the organelle a protein is supposed to be targeted to, acting like address labels," said Dr Li. "When we found that they also contain the information for the age selectivity we observed, we decided to try to identify the "code" that instructs a protein to go to older chloroplasts first. The existence of such a code means that chloroplast signal peptides are not just address labels - they also contain information about "when" a protein should be delivered."

These findings may have implications for selectively targeting proteins into organelles of aging tissues, said Dr Li. "We believe similar kinds of regulation mechanisms may also exist for other organelles in other organisms, like humans. For example, there may be signal peptide motifs that will allow us to specifically target therapeutic proteins into mitochondria in aging cardiac tissues."

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