

CYTOKININS-overview

1892 Weisner

Cell division in plants may be controlled by a specific substance.

One way to study plant hormones would be to examine the action of hormones on individual cells.

1902 Haberlandt tried unsuccessfully to stimulate cells to divide in vitro

“Without permitting myself to pose more questions, or to prophesy to boldly, I believe that it will be possible to grow, in this manner, artificial embryos from vegetative cells”

(From Steward FC, Growth and Organization in Free Cell Cultures)

1913 Haberlandt

Phloem diffusates induce cell division in potato parenchyma

Therefore, there is a cell division substance

1921 Haberlandt

Cell division induced by wounding is prevented by rinsing the wounded surface

Cell division is restored by applying chopped up tissue to the wounded surface.

The cell division substance may be a small molecule

1941 Skoog

Plant tissue culture technologies just developing.

Could cells be induced to grow normally as cells in vitro?? Would the addition of nutrients and the known plant growth regulator, auxin, be sufficient to induce normal growth??

Stem internode tissue of tobacco did not grow in culture unless the hormone auxin is added.

When auxin was applied alone to tobacco stem pith the cells enlarged, but did not divide.

Vascular tissue also elicited cell division.

What natural sources could be found that contained related compounds that could act to stimulate cell division??

Tobacco stem extract gave inconsistent results.

Coconut milk, malt, yeast extract, autoclaved herring sperm DNA all stimulated cell division in the tobacco pith assay.

1955-6 Miller et al.

Kinetin (furfurylamino purine) chemically identified from herring sperm autoclaved DNA as the chemical that stimulated cell division.

Turns out that kinetin is an artifact due to autoclaving DNA. It is formed by the reaction between adenine and deoxyribose or by a complex reaction involving dehydration and rearrangement of deoxyadenosine residues while they are still polymers.

Kinin was proposed as the name, but since this name was already used for animals, cytokinin was coined (Skoog) (cytokinesis = cell division)

Even though kinetin was known to be an artifact, it was clear that some possibly related compound functioned in vivo as a cytokinin.

1963-64 Letham

A cytokinin was isolated and its structure determined from maize kernels

Either because Letham was from New Zealand, or because the compound was isolated from *Zea* maize, he called it ZEATIN.

60 kg of material were required

Cytokinins implicated in:

de novo bud formation in tobacco callus

reversal of apical dominance: axillary buds grow

cell division in tobacco pith

plastid morphogenesis

reversal of senescence in Xanthium leaves

betacyanin production in dark-grown Amaranthus seedlings

stomate opening

de-etiolation-plants grown in dark or dim light appear as if grown in bright light

Cytokinins may be synthesized in the roots of plants

Cytokinins found in many plant tissues, however, their high level in root tips and xylem tissue has been taken as indirect evidence that they are synthesized in roots and translocated through vascular tissue to shoots. Much circumstantial evidence exists to corroborate this, in particular that Cytokinins are secreted continuously from the xylem exudate of roots.

Cytokinins from root are thought to control shoot development:

excised leaves and derooted shoots undergo rapid senescence and decline

formation of adventitious roots on excised leaves or shoots -delays or reverses senescence
-occurs if increased exogenous cytokinin levels to these organs

stresses to roots (high temperature, high osmotic, salt, desiccation) cause both a decrease in cytokinin levels in roots and an increase in senescence in leaves and growth of shoots

exogenous cytokinins can reverse the above effects in some cases

correlations exist between senescence of the whole plant, bud burst, flowering and cytokinin levels in some cases.

CYTOKININ METABOLISM

.....remains an area which is very unclear.

Subcellular site of synthesis, compartmentation not known (plastid or cytoplasm?).

Wide variety of CKs (including conjugates) identified as natural products

30+ unusual bases occur in tRNA of all kingdoms

Cytokinins are always located 3' of the anticodon

Similarities to adenine and derivatives complicate analysis and understanding of pathway.

No CK deficient mutant yet identified.

CK overproducers :

Moss:

OVE mutant has 100x increase in CK, and an increase in gametophores (the structures that bear the gametophytes).

Plants:

CK overexpression in plants generally results in:

- Decreased apical dominance
- Increased SAM size
- Delayed senescence
- Increased ectopic shoots especially on leaf discs

Tobacco:

- BM3 tumors have increased CK, CK independent growth.

Agrobacterium transgenes:

- *RolC* and *isopentenyl transferase (ipt)* each of these increase CK accumulation when overexpressed in plant.
- When *ipt* is overexpressed using heat shock promoter, areas of leaf exposed to heat shock show increases cytokinins, increase accumulation of KNAT and SAM mRNAs, and delayed senescence.