PONTIFICIA
ACADEMIA
SCIENTIARVM

COMMENTARII

VOL. II N. 6

EDWARD JOSEPH CONWAY

THE ACTIVE TRANSPORT OF INORGANIC CATIONS ACROSS THE YEAST CELL MEMBRANE

EX AEDIBVS ACADEMICIS IN CIVITATE VATICANA

PONTIFICIA
ACADEMIA
SCIENTIARVM

COMMENTARII
Vol. II - N. 6
pag. 1-4

THE ACTIVE TRANSPORT OF INORGANIC CATIONS ACROSS THE YEAST CELL MEMBRANE

EDWARD JOSEPH CONWAY
Pontifical Academician

SVMMARIVM — Ex ratione qua varii inorganici cationes, qui in plantarum cellulis insunt, transportantur, Auctor concludit unum esse transportatorem (« physiologicum K-transportatorem »); eumque non esse systema quoddam ATP-asicum, sed verisimilius cytochromum vel aliquid quod in operando sit cytochromo simile.

This short paper is presented to the Academy in the belief that the facts presented therein, amount to a definitive demonstration of the validity, in a vegetable cell, of one of the main theories of active transport of inorganic cations, which may be said to be the ATP-ase theory and the Redox pump theory.

Prior to this some introductory statements may be made. Firstly, in the yeast cell wall there is present a carrier of inorganic cations which we have termed « the physiological K-carrier ». It is so called because its affinity for inorganic cations is highest for potassium.

Paper presented on April 22th, 1966 during the Plenary Session of the Pontifical Academy of Sciences.

Yet, all the inorganic cations can be taken up by this carrier, when the suspending fluid is buffered to a pH of about 7.0, and glucose is present in 5 per cent strength. Representing the K affinity as 100, that for sodium is only 3.8. Rubidium and caesium have intermediate values of 42, and 7 respectively, while that for lithium is only 0.5. The affinities of the divalent cations, Mg^{2+} and calcium Ca^{2+} is approximately 0.5 and 0.2 respectively. The affinity for H^+ ions is highest of all being (in terms of the K figure 1380, and this is why comparisons with cations having weak affinities can only properly be made when the pH is at least 7.0 and the H^+ ion concentration is then negligible when dealing with inorganic cation levels of the order of 0.2 M.

When the cation species is in general of the order of 0.2 M and the pH approximately 7.0, these various inorganic are taken up to about the same extent, but at very different rates, the rates being related to the relative affinities.

The same carrier?

That the same carrier is used for all the various inorganic cations present when these are taken up individually and at a pH of about 7.0, and in concentration of approximately 0.2 M is shown by the following facts:

1) When they are used in pairs the two species compete for the same active group on the carrier as shown by the facts of mutual competition and the application of Michaelis-Menten kinetics, as in the Lineweaver and Burk equation (1934). Data for the competition of K and Na are given by Conway and Duggan (1958) and of the mutual competition of Mg and Rb by Conway and Beary (1958).

2) When the cation is taken up and accumulated an equivalent amount of H^+ ions are set free into the suspending medium. This is at once apparent when no buffer is used and potassium ions are taken up. The hydrogen ions released in free solution into the suspending fluid are then about the same as the potassium ions absorbed. By using starved yeast and as little suspending fluid as possible, a pH of 1.5 can be reached therein, which is the same in H^+ ion concentration, as found in the gastric juice as a whole and has a similar explanation. It may also be observed in a buffered suspending medium as when magnesium ions are taken up in quantity at a pH of 7.0 (Conway and Beary, 1958).

3) The mere fact that as little as 0.58 micro moles per ml of potassium ions in the external fluid can reduce the uptake of Magnesium by about 50% or from about 200 to 100 micro-mole/g (Conway and Beary, 1958) shows that potassium ions are then displacing magnesium ions from the carrier.

(Here it may be mentioned that Rothstein, 1954, developed a special mechanism for the transport of divalent cations at a pH of 5.0. This carrier was very different from the carrier considered above, and there was no inhibition by potassium).

The essential facts of the K uptake as illustrated by magnesium.

a) In a review of the uptake of magnesium it may be said that this uptake can be considerable at a pH of 7.0 or 7.4, being 200 or more millimols. per kg. It can be easily displaced by potassium ions from the carrier.

b) Its uptake is completely inhibited by anoxia and cyanide (0.2 mM).

c) An equivalence of hydrogen ions are excreted at the same time as the magnesium absorption.

All this is irreconciliable with the action of an ATP-ase system acting as carrier.

With regard to the mechanism of action one may say that the carrier is a cytochrome or is cytochrome-like in action.

When metabolic hydrogens are carried to it, and the carrier placed at the extreme edge of the cell, hydrogen ions are split off and electrons; the electrons being then carried forward to oxygen, and forning the requisite transport for cations, or magnesium ions as here.

REFERENCES

Conway E.J. and Douglas W.F., « Biochem. J. »,*69*, 265 (1958).

Conway E.J. and Beary M., « Biochem. J. », *69*, 277 (1958).

Lineweaver H. and Burke D., « J. Amer. Chem. Soc. », *56*, 658 (1934).