Relative Strontium and Calcium Uptake by Green Algae

Kevern (*1*) reports that *Oocystis eremosphaeria*, a green alga, takes up strontium as a substitute for calcium when calcium is limited. He says this "suggests that the alga requires either element." I agree with the author that there is more concentration of ^{90}Sr than generally believed in living organisms, whether low or high levels of calcium are present, and that calcium-strontium ratios are often improperly used "to predict or interpret the behavior of ^{90}Sr in the environment." But my experience with *Pithophora oedogonia* (*2*) and other green algae (unpublished data) indicates that they cannot substitute Sr for Ca for their basic metabolic needs. Kevern's figures clearly show more uptake of Ca than Sr at the lowest Ca concentrations. Furthermore, he does not report how much Ca was transferred with the algal cells cultured in concentrations of Ca and Sr reported to be in the range found in freshwater environments. Could the amount of Ca in the cells of the inoculum have been sufficient to meet the basic metabolic needs for Ca during his experimental runs? Algal cells are known to transfer nutrients for many generations.

O'Kelley and Denton (*3*) have shown chemical compositional differences between algal cells grown in Ca and in Sr-replacement, and Gilbert and O'Kelley (*4*) have shown marked structural and reproductive differences in the green alga *Chlorococcum* when the Ca is replaced by Sr. My experience indicates that the presence of Ca at metabolic concentrations in cultures of green algae greatly increases the uptake of Sr; therefore, these two elements are not exchangeable at their limiting nutrient concentrations.

No algal blooms would occur in these species without Ca. When enough Ca is present and other conditions are favorable for algal growth and metabolism, the result is a relatively larger algal mass, which has the capacity to accumulate relatively more Sr. I found (*2*) that uptake in non-living organic materials supports Kevern's conclusions; and I fully agree with his suggestion that uptake of ^{90}Sr fallout could be reduced significantly by the addition of Ca at concentrations above the nonmetabolic exchange levels. When there is not enough Ca, however, to meet the requirements for Ca, there will be no significant algal mass present to take up the Sr.

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References

1. N. R. Kevern, *Science* **145**, 1445 (1964).
2. L. G. Williams, M. Howell, C. P. Straub, *ibid.* **132**, 1554 (1960).
3. J. C. O'Kelley and T. E. Denton, *Assoc. Southeastern Biologists Bull.* **11**, 52 (1964).
4. W. A. Gilbert and J. C. O'Kelley, *Am. J. Botan.* **51**, 866 (1964).

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It is apparent from published data that the green algae are diverse in their responses to strontium. Walker (*1, 2*) has reported three different responses to strontium by green algae: *Chlorella pyrenoidosa* and several unidentified *Chlorella*-like strains can utilize strontium in place of calcium for most, if not all, of their requirements; *Scenedesmus obliquus* and *Selenastrum minutum* cannot substitute strontium for calcium and are not inhibited by strontium, while the growth of *Coccomyxa pringsheimii* is inhibited by strontium. Since *Oocystis* and *Chlorella* are in the same family, Oocystaceae, it might be suspected that they would have the same response to strontium, whereas *Pithophora oedogonia*, a filamentous alga, and *Protosiphon botryoides* (used by O'Kelley and Denton), a terrestrial, coenocytic alga, might well have a different response. I did not intend to imply that my suggestion of strontium substitution for calcium by *Oocystis* could be extended to all green algae. The implication is that the pattern I reported would be true in systems containing plants that did substitute strontium for calcium. Williams seems to be making a generalization for all green algae based on studies of particular species.

The point is well taken that the calcium transferred with an inoculum may have been sufficient for many generations. The data on uptake were reported for the two runs of the study for the time after 6 and 7 days. At these times the algal populations had increased to about 3 times the original mass, and growth continued until the mass was 10 times the original inoculum. The sufficiency of the calcium transferred in the cells of the inoculum would thus be considerably diminished in 6 days and would be diminished even more during the remaining time. Although the quantitative metabolic requirement for calcium is admittedly low, it is unknown for the alga I studied and for nearly all other green algae. Thus, it is impossible to say whether or not the requirement for calcium was being met. This is one reason why I stated that the data *suggested* a strontium replacement for calcium at low calcium concentrations. Otherwise, the data indicate a chemical equilibrium reaction.

Williams fails to offer any other explanation for strontium uptake except to say that green algae cultured in media containing metabolic concentrations of calcium take up increased amounts of strontium. He does not say, explicitly, whether the strontium uptake is an increase over that taken up at limiting calcium concentrations or at higher calcium concentrations. If the strontium uptake increases in algal cultures when calcium is increased from limiting to metabolic concentrations, it is exceedingly important to have used specially purified calcium compounds. Otherwise, increasing the calcium concentration increases the strontium concentration in the same proportion and results in an increase in strontium uptake, as was shown in my report.

The discussion of algal blooms is not pertinent to my data, which were reported as uptake of strontium per unit weight of algae. Williams' last point may be correct if the species involved cannot substitute strontium for calcium. However, it is not true for all green algae; Walker (*1*) has demonstrated, and my data suggest, that some green algae do substitute strontium for calcium.

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References

1. J. B. Walker, *Arch. Biochem. Biophys.* **46**, 1 (1953).
2. ———, *ibid.* **60**, 264 (1956).

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