then correspond to 17- to 26-percent conversion, which is certainly consistent with the relative intensity of the lines of the new phase compared with the untransformed graphite.

The new phase is relatively stable at atmospheric pressure, as heating in a vacuum at 450°C for 6 hours gave no appreciable diminution in the intensity of the x-ray lines characteristic of this phase.

As we have shown, the single crystal graphite is only partially transformed. Pyrolytic graphite is only slightly transformed, and no indications of transformation have been found from powdered graphite. Evidently, the transformation can occur at a measurable rate only where there are relatively large areas of rather perfect crystal. It would seem possible that with unusually fine single crystals of graphite a very substantial conversion could be obtained. This would permit the identification of more lines, and reasonably accurate intensity determinations, so that the details of the structure could be determined. It would seem at present that this form of carbon may be analogous, in a general way, to the denser forms of germanium and silicon which have recently been reported as metastable at 1 atm (*3*), although it is formed from graphite, not from the diamond structure. In view of the marked increase in resistance at the transition, this new structure is not similar to the metallic forms of Si and Ge previously found at high pressure (*4*), which are reported by Jamieson (*5*) to have the white tin structure (*6*).

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Cadmium: Uptake by Vegetables from Superphosphate in Soil

Abstract. *Phosphates in fertilizers contain cadmium. When vegetables usually devoid of cadmium were grown in soil heavily fertilized with 20 percent superphosphate, they absorbed it. Vegetables normally containing cadmium absorbed larger quantities in the presence of superphosphate and little or none in its absence. The superphosphate showed 7.25 parts of cadmium per million. Five grains usually containing cadmium were grown in unfertilized soil poor in this element; four did not absorb it. Phosphate fertilizers may be a source of the cadmium in some vegetable foods.*

Cadmium accumulates with age in the human kidney and liver (*1, 2*), although variations in concentration in these organs from different areas of the world are large (*3*). The principal sources of cadmium for man are mollusks, crustaceans, and grains (*2*). Although cadmium is not always present in food, certain vegetables and grains produced with heavy applications of commercial fertilizer (*4*) have shown relatively high concentrations (*2*). We found 9 to 36 parts of cadmium per million in the phosphate fractions of five fertilizers. Others have reported even larger amounts in phosphorites from Jamaica (*5*) and Oceania (*6*), although a sample from Tennessee contained only 0.41 ppm. The source of cadmium in phosphates is undoubtedly sea water, for natural phosphate rock is partly composed of the hard parts of marine animals of Plio-Pleistocene or Tertiary time (*5*). Marine phosphorite deposits in Florida provide most of the phosphates in fertilizers used in the United States. In 1961 almost 3 million metric tons of P_2O_5 for domestic agricultural uses and 1 million tons for export were produced in this state (*7*). Therefore, two questions required answers: Could phosphates supply cadmium to growing vegetables? Could grain be grown free of cadmium?

A plot, situated on a slope on an isolated hilltop in Vermont, measuring 20 by 18 m was divided into four subplots each 5 by 18 m. There was little drainage between them, as their slopes were similar. Fertilizer had not been applied to our knowledge, and the chance of industrial contamination in this location is remote. The soil contained no detectable cadmium. Two subplots served as controls. A third received a heavy application of composted wood chips and manure, approximately 100 kg being spread thickly in seed rows. One horse provided the manure; he had fed on oats, containing 0.02 ppm Cd, and on pasture grass, hay, and water which had no detectable Cd. The wood chips showed 0.05 ppm Cd. The fourth subplot received an application of 20 percent superphosphate containing 7.25 ppm Cd; 25 kg were broadcast and 20 kg were laid in drills in close contact with seed. A garden was planted in rows passing through all four sections at right angles to the slope; it was watered only by rainfall. The mature vegetables and others purchased from local chain stores were carefully washed in deionized water, ashed at 400°C, and analyzed by the Saltzman method (*8*) with minor modifications (*2*). Fertilizers and soil samples were extracted with concentrated HCl or aqua regia (Table 1).

In order to expose growing plants to high concentrations of phosphate, three wooden window boxes were filled with forest top soil containing 0.34 ppm cadmium. One window box served as control, the soil in the second was mixed with about 25 percent by volume

Table 1. Cadmium in garden vegetables and soil (in micrograms per 100 g wet weight). N.D., not detected. There was no uptake of cadmium from superphosphate by corn, turnip leaves, lima beans, or radish leaves. Commercial lima beans and locally grown corn contained no detectable cadmium; frozen corn and corn meal showed 7.5 and 6.5 μg/100 g, respectively. Turnip and radish leaves were not available commercially.

Vegetable	Control	Compost-manure	Superphosphate	Chain-store vegetables
		Garden		
Lettuce, iceberg	N.D.	N.D.	4.0	1.0
Lettuce, early curled	N.D.	0.3	0.5	1.7
Turnips, roots	N.D.	N.D.	3.0	2.0
Radishes, roots	N.D.	N.D.	2.0	1.5
Parsnips	3.0	3.0	14.0	2.8
Potatoes	N.D.	N.D.	0.3	N.D.
String beans	N.D.	N.D.	0.3	N.D.
Beets	N.D.	N.D.	0.9	N.D.
Onions	N.D.	N.D.	0.3	N.D.
Peas, green	N.D.	N.D.	1.0	N.D.
Carrots	N.D.	0.7	0.8	N.D.
Garden soil (dry wt.)*	N.D.	18.8	31.1	
		Window box		
Peas, green, leaves†	0.3	1.0	13.0	
Peas, green, shelled†	N.D.	N.D.	3.3	N.D.
Swiss Chard	‡	‡	1.7	2.9
Beets	‡	‡	4.1	N.D.
Turnips, roots	0.3	0.3	1.0	2.0
Forest soil (dry wt.)§	34.0	67.1	130.5	

* The *p*H of all sections of the garden was 7.0. The soil had been limed the previous year. The sample from the phosphate-treated plot was taken from between rows. † Pea seeds contained 1.0 μg of Cd per 100 g. ‡ Poor growth, insufficient size for analysis. § Forest topsoil was used in the window boxes. Foliage from nearby trees contained Cd (*2*). The *p*H was 7.0 in the boxes treated with compost and manure; in the other boxes it was 6.0.

Table 2. Cadmium in soil, commercially grown grains and seeds, and grains grown in an abandoned pasture (in micrograms per 100 g wet weight). N.D., not detected.

Grain	Commercial feed	Commercial seed	Pasture grown
Rye	N.D.	N.D.	N.D.
Oats	8.1 to 12.7	N.D.	N.D.
Wheat	5.7 to 13.0	1.0	4.6
Barley	1.0	1.0	N.D.
Millet	*	4.0	N.D.
Buckwheat	7.2	N.D.	N.D.
Soil†			N.D.

* Not available. † Soil of the long-abandoned pasture had been limed 2 years previously; the *p*H was 5.5. The subsoil undoubtedly contained Cd.

of the composted wood chips and manure, and the third received a heavy application of superphosphate, approximately 10 percent by volume. Four vegetables were planted and watered with doubly deionized water. Growth was lush in the box treated with superphosphate but poor in the others. The mature vegetables were analyzed for Cd (Table 1).

In order to grow grains in a cadmium-free environment, a long-abandoned pasture in a remote forest was cleared, plowed, limed, and planted with rye. Both the soil and the crop were free of cadmium. The next year five plots, each 10 by 40 m, were rototilled and planted heavily with buckwheat, wheat, oats, barley, and Hungarian millet. No fertilizer was applied. The mature grain was threshed by hand, metallic contamination being carefully avoided. Commercial feed, the seed planted, and the grain grown by us were analyzed (Table 2).

Our experiments indicate that superphosphate can be a source of the cadmium in certain vegetables. Several of the commercial vegetables which do not ordinarily contain detectable cadmium can absorb it in the presence of high concentrations of phosphate. Other vegetables usually containing cadmium can be grown without it appearing in the mature plant. Furthermore, certain grains ordinarily containing cadmium can be grown free of this trace metal, although wheat appears to be an exception. Presumably the cadmium in most commerical grains and many vegetables comes partly from that in marine phosphorite deposits, for phosphate fertilizers are widely used on grain-producing lands and truck gardens (*4*). Although the ultimate source was the sea, sea water now contains little cadmium (1 part in 10^9) (*9*). We could not find cadmium in water samples from Cape Cod, although a commercial sea salt from Texas contained 0.13 ppm.

Cadmium is undoubtedly present in the subsoil of our area, for we have found it in leaves, twigs and bark of forest trees (*2*). The earth's crust contains 0.18 ppm Cd (*6*), an amount comparable with that in our forest soil. Although it was not detected in untreated garden and pasture soils, a small amount must have been available since it was absorbed by parsnips and wheat. The area cultivated is one of heavy rainfall and excessive leaching of trace metals from exposed soils.

The amount of cadmium in vegetables exposed to phosphate appears to be small. The mean daily dietary intake of Americans, however, has been estimated as only 23 μg of Cd, of which 3 μg is retained in the body, mainly in kidney and liver (*2*). An institutional diet (2500 calories per day) contained 18 μg. By comparison the concentrations of 1 to 4 μg/100 g in these vegetables are relatively large.

There seems to be no evidence at this time that cadmium is an essential trace metal for mammals. Rats and mice were reared successfully on a cadmium-free diet, none being found in their tissues; others given small amounts of cadmium have had considerably higher mortalities when renal concentrations were approximately one-fourth those of adult Americans (*10*). Female rats fed cadmium in small doses have exhibited hypertension, often severe (*11*) at these same renal concentrations. The mammalian body apparently has no homeostatic mechanism for cadmium (*12*), unlike the "essential" trace metals. Pathways by which cadmium enters food and the body of man are therefore important to explore (*13*).

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Helicoplacoidea: A New Class of Echinoderms

Abstract. *A fusiform, spirally coiled and pleated, free-living, heavily placate echinoderm with an expansible test has been discovered in the Lower Cambrian* Olenellus *zone of California. It is characterized by 10 "interambulacral" areas, a single principal endothecal ambulacrum with a short branch, and oral and apical regions at opposite poles. A new class, the Helicoplacoidea is proposed for the new genus* Helicoplacus, *with two new species,* H. gilberti *(type species) and* H. curtisi.

At least 31 specimens of a striking new type of echinoderm, some essentially complete, others fragmentary and exceedingly numerous dissociated plates have been collected from a shale with graded bedding near the base of the upper member of the Poleta Formation, Lower Cambrian (*1*) in the Westgard Pass area of the White-Inyo Mountains, about 15 miles southeast of Bishop, California. The new form is found at three localities (*2*) scattered over an area of perhaps a square mile, about 1 mile west of the highway. The specimens occur in beds in which trilobites are common (occasionally on the same bedding surface) and which are perhaps 25 feet above the lower, archaeocyathid-bearing limestone of the Poleta Formation. Archaeocyathids are also found in overlying beds. The pedunculate echinoderm *Eocystites* occurs at approximately the same stratigraphic position and may possibly occur in the same bed. The beds in which the new form occurs fall within "beds with the very abundant *Nevadella gracile* (Walcott) fauna, approximately 2500′ above