Table 1. Group mean scores for experimental and control groups.

Group	Trials to criterion (*N*)	Errors to criterion (*N*)	Overt errors (%)	Fluctuation cycles (*N*)	Efficiency ratio
		Pretest			
Experimental	18.2	139.0	17.4	19.6	0.14
Control	20.1	150.8	14.4	23.0	.17
		12 hours			
Experimental	21.2	153.8	13.4	27.2	.24
Control	21.1	147.2	19.7	24.8	.21
		24 hours			
Experimental	15.0	96.1	15.8	17.7	.23
Control	17.8	115.5	12.7	19.8	.19
		36 hours			
Experimental	18.7	125.8	16.9	24.1	.16
Control	16.3	116.6	13.1	19.1	.17
		48 hours			
Experimental	13.0	85.9	14.4	13.3	.15
Control	14.4	106.5	12.6	13.2	.07
		24 hours after test			
Experimental	16.0	82.5	19.0	17.8	.26
Control	14.4	98.8	10.7	17.5	.17

aurally by tape recorder. One list was for preliminary testing; four were for testing during the experiment; one was for testing after the experiment. Each list was presented in repeated trials until the subject had learned the words. The first list was presented when the subject reported for the study. Lists 2 through 5 were presented at 12, 24, 36, and 48 hours, respectively, after the beginning of his confinement. The final list was presented 24 hours after his release. The subject was in the cubicle for all tests. The interval between presentation of the adjectives was 2 seconds, and the interval between trials was 5 seconds. The method of anticipation was used: after hearing the list once the subject, on the next trial, says the word he expects to hear next via the tape recorder before it is presented. The learning criterion was one errorless trial.

The subject was told in advance how long he would be confined and was told that he would not be spoken to at any time and that hallucinations, delusions, or other phenomena sometimes occurred as a consequence of such isolation. He was also told that he would be extensively interviewed regarding his experiences, after completion of the tests. For meals and toilet needs (on demand) he removed the tubes and gloves but kept the goggles on. He ate his meals in the cubicle, seated on the edge of the cot.

The results were analyzed in terms of group mean differences (results for the subjects minus results for the controls) for five types of analysis: trials to criterion, errors to criterion, percentage of overt errors, fluctuation cycles, and efficiency ratio (*3*). Group mean scores were compared by *t* tests, and variances were compared by *F* ratio. Analyses were made for each 12-hour period of deprivation. Another analysis, comparable to that of Vernon and his co-workers, was made of the composite, overall score for the total deprivation period. Differences in all instances and for all comparisons were not significant at or beyond the .05 level—a finding that indicated the performance for the two groups to be essentially the same, regardless of the period of confinement. Table 1 shows the group mean scores for the two groups for each testing. These findings are not in agreement with those of Vernon and McGill (*3*), who found that their experimental group scored higher during confinement on percentage overt errors, on fluctuation cycles, and on efficiency ratio. However, since these investigators grouped under one heading results for all tests during the deprivation period, it is impossible to determine whether the higher scores were characteristic of their experimental group throughout the study or only at specific times.

There were two points of special interest in our findings. (i) Learning was not facilitated by confinement, but neither was learning ability lessened. [Vernon and his associates (*2*, *3*) found evidences of improved performance, but most of the literature on sensory deprivation reports psychological dysfunction and deficit.] (ii) In no instance did any subject report hallucinatory, delusional, or other unusual phenomena as occurring at any time during the entire period of confinement. All subjects maintained relatively adequate time orientation and reported that they were aware of the approaching termination of the experiment. We believe that the initial structuring of the experimental situation for the subjects may have played a major role in their behavior.

Our findings, contrary to findings reported in earlier work (*1*), indicate that whatever the requirements of the adult, human organism for external and varied stimulation, reduction or patterning of input will not, alone, produce major disruptive psychological effects. Such results are the product of a complex interaction of personality, anxiety, expectation, situational structuring, and amount and patterning of external sensory input (*5*).

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20 September 1962

Carbon-Isotope Composition and the Origin of Calcareous Coal Balls

Abstract. The C^{13}:C^{12} ratios of the carbonate comprising "normal," "faunal," and "mixed" coal balls are consistent with the hypothesis that calcareous coal balls contain varying proportions of two kinds of carbonate: (i) precipitated carbonate formed in the coal swamp and characteristically deficient in C^{13}, and (ii) extraneous detrital material, mainly fossil fragments relatively enriched in C^{13}.

Although nodular, plant-bearing carbonate masses (coal balls) found in certain coal seams in Europe and America have been reported for well over a century, American coal balls containing marine organisms were first

described relatively recently (*1*). Detailed accounts of marine animal remains have been provided by Mamay and Yochelson (*2*), who distinguish four major types of coal balls: (i) "normal" coal balls, containing only plant remains; (ii) "faunal" coal balls, containing only fossils of marine animals; (iii) "homogeneous mixed" coal balls, containing intermixed faunal and floral remains; and (iv) "heterogeneous mixed" coal balls, containing cores of marine-fossil-bearing carbonate, mantled by "normal" plant-bearing carbonate. Previously, all coal balls had been considered to be of concretionary genesis (*3*), but the faunal and textural evidence of Mamay and Yochelson suggests that coal balls may include some material of clastic origin, and those authors envisage an influx of clastic marine carbonate by seawater invasions of coastal swamps during times of high tides and unusual wave action. They point out, however, that the only physical evidence of marine invasion is the presence of marine organisms in "mixed" and "faunal" coal balls within the coal seams.

Detailed studies of carbon- and oxygen-isotope ratios in freshwater and marine carbonate rocks (*4, 5*) have shown the importance of carbon-isotope composition as a geochemical indicator for differentiating carbonate material deposited in freshwater and marine environments. If Mamay and Yochelson are correct in concluding that marine carbonate has been injected into a freshwater environment, either as a mud slurry or as poorly consolidated ellipsoidal "wave rollers," determinations of C^{13}:C^{12} ratios should substantiate their findings. For this reason, representative samples of American coal balls, furnished by S. H. Mamay of the U.S. Geological Survey, were subjected to isotopic analysis.

Carefully cleaned carbonate material removed from coal-ball specimens was crushed to −80 mesh particle size prior to heating for 20 minutes at 420°C in flowing helium—a treatment designed to remove volatile organic compounds. The residue was treated with orthophosphoric acid (100 percent) under vacuum, and carbon dioxide was evolved in the reaction over a 24-hour period. The carbon dioxide was purified and analyzed isotopically with a 6-inch, 60°-sector mass spectrometer with an isotope-ratio recording system, similar to that described by McKinney *et al.* (*6*), in which the isotopic ratio of the sample gas is compared with that of a carbon dioxide standard gas. Isotope ratios are expressed as the difference in C^{13} content (δC^{13}, in parts per thousand) relative to the C^{13} content of the Chicago PDB standard CO_2 (*7*) by the relationship:

$$\delta C^{13} = 1000 \left(\frac{C^{13}/C^{12}_{\text{sample}}}{C^{13}/C^{12}_{\text{PDB std}}} - 1 \right)$$

and are corrected for the presence of O^{17} in the gas samples, as described by Craig (*8*). Carbon dioxide subsamples were prepared and analyzed in duplicate from each carbonate sample, with a total analytical random error for δC^{13} of less than 0.2 per mil.

Table 1. Isotopic composition of selected Pennsylvanian age American coal balls.

Sample No.	δC^{13} (‰)	δO^{17} (‰)	Locality	Coal seam	Mineralogy
			Normal		
67–253	−22.08	−7.58	McAlester, Okla.	Secor	Calcite, minor dolomite
67–254	−23.35	−7.26	Berryville, Ill.	Calhoun	Calcite, trace dolomite
			Faunal		
67–259	−3.80	−8.92	Monmouth, Kan.	Beviar	Calcite, trace dolomite
			Homogeneous mixed		
67–252	−11.40	−7.03	McAlester, Okla.	Secor	Calcite, minor dolomite
67–258	−6.79	−9.65	West Mineral, Kan.	Fleming	Calcite
			Heterogeneous mixed		
67–255*	−13.89	−7.80	Berryville, Ill.	Calhoun	Calcite, trace dolomite
67–256†	−20.72	−7.57	Berryville, Ill.	Calhoun	Calcite, trace dolomite

* Marine faunal mixture from core of coal ball. † "Normal" exterior of same coal ball.

The isotopic results are shown in Table 1 and may be compared to the ranges of carbon-isotope composition of marine mollusk shells, (+4 to −2 per mil) and of fluvial and lacustrine mollusk shells (−2 to −14 per mil) (*5, 9*). A "normal" coal ball from the Secor coal of the Boggy formation at McAlester, Oklahoma, and another from the Calhoun coal of the McLeansboro group at Berryville, Illinois, exhibit extreme deficiency in C^{13}, with levels well below the range of freshwater organic carbonates and comparable to those of land plants (*9*), and presumably due to carbonate precipitation from paludal waters in which much of the dissolved carbon dioxide and bicarbonate had been derived from plant decomposition. In contrast, the carbonate from a "faunal" coal ball, containing marine faunal remains exclusively, from the Beviar coal at Monmouth, Kansas, shows a much higher C^{13} content, approaching that of marine mollusk shells.

Intermediate δC^{13} values, for two "homogeneous mixed" coal balls from the Secor and Fleming, seams, respectively, (samples 67-252 and 67-258) are consistent with the hypothesis that those particular coal balls contain a mixture of marine organic carbonate and paludal precipitated carbonate. In this case the isotopic evidence alone is not sufficient to provide an unequivocal answer, because the isotopic compositions are within the range of lacustrine and fluvial organic carbonates. However no freshwater shells were found in the coal balls investigated.

The isotopic effect of a combination of two types of carbonate in various proportions is further illustrated by separate analyses of the core and the exterior of a "heterogeneous mixed" coal ball from the Calhoun seam at Berryville. The core, containing visible marine fossils, contains more C^{13} than the exterior, which consists of the "normal" carbonate, containing only plant remains.

A full understanding of the significance of the carbon-isotope composition of calcareous coal balls would require comparison of coal balls from strictly continental sequences and coal balls from seams which show evidence of marine influence. However, the few analyses presented here are consistent with the contention of Mamay and Yochelson (*2*) that some coal balls include clastic marine carbonate material which has been introduced into the paludal environment of peat deposition. It follows that the origin of the calcareous coal balls must have been contemporaneous with peat accumulation and that they are not postdepositional concretions (*10*).

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12 September 1962

Postvernalization Seed Treatment with Vitamins in Vigna catjang

Abstract. Thermoinduction for 1 week, followed by 48 hours of vitamin treatment of seeds, resulted in complete annihilation of the cold effect, the plants from the treated seeds having shown a significant increase in elongation of the root and shoot and an increase in the fresh weight as well as in the dry matter over vernalized and unvernalized controls. An increase in vegetative vigor was also noted after treatment with vitamins at lower concentrations in the unvernalized series. Cold treatment not combined with vitamin treatment resulted in a decrease in vegetative vigor.

Comparatively little work has been done on the effects on the growth of plants of low-temperature vernalization and subsequent vitamin treatment of the seeds, as compared with the tremendous amount of work that has been done on the interacting effects of low temperature and growth regulators (*1*) and on the effect of vitamins alone on the growth of plants (*2*). The experiment reported here was carried out in order to study the physiological reactions of plants from seeds subjected to low temperature and subsequent vitamin treatment. Preliminary work, carried out with the vitamin riboflavin, on the growth of *Vigna* (*3*) and pea (*4*) had shown interesting but not very significant stimulating effects on the early growth of unvernalized seeds.

Seeds of homozygous pure strains of the common Indian pulse *Vigna catjang* var. pushaphalguni, obtained from the State Agricultural Experiment Station of Orissa at Sambalpur, were used in this investigation. The seeds were soaked in distilled water for 24 hours, then subjected to low-temperature treatment at 3° to 5°C for 1 week.

The vernalized seeds were then separated into ten lots of 15 seeds each and treated with riboflavin and ascorbic acid, alone and in combination, at concentrations ranging between $10^{-3}M$ and $10^{-5}M$, for 48 hours. The seeds were then washed in distilled water, sown in earthenware pots containing garden soil, and grown under field conditions. The plants were harvested after 2 weeks, and data were recorded. In another series the low-temperature treatment was omitted; we refer to this series hereafter as the "unvernalized series." Seeds treated with distilled water and low temperature for 1 week, then treated with water for another 48 hours, served as controls for the vernalized series; the low temperature treatment was omitted for the controls for the unvernalized series. In Table 1 the data obtained for the two series are expressed as percentages of growth of the respective controls.

In the vernalized series the elongation of the root and shoot was significantly higher in the plants grown from vitamin-treated seeds than in the controls when the riboflavin and ascorbic acid were applied singly or in combination at the lower concentrations, but riboflavin alone at a concentration of $10^{-3}M$ was inhibitory. The most interesting result was the failure of the seeds to grow when the vitamins were used in combination at the highest dosage. For the unvernalized series low concentrations of the two vitamins, alone or in combination, stimulated growth, the effect being less pronounced than in the vernalized series.

The changes in the levels of weight accumulation of roots and shoots for the vernalized series were very significant. Treatment with vitamins produced a significantly progressive increase in the increment of both fresh weight and dry weight of root and shoot, with decrease in the concentrations of the vitamins used, alone or in combination. In the unvernalized series, vitamins at the two lower concentrations promoted growth if used singly and did so even more if used in combination. Calculation, from the actual dry weight of plants, of the top-to-root ratio showed that the ratio increased progressively with decrease in concentrations of ascorbic acid in the vernalized series. Riboflavin had no effect on the ratio. When the vitamins were used in combination at the two lower concentrations, the ratio was higher than it was in the controls, indicating a promotive effect on shoot growth. The ratio was not significantly altered for the unvernalized series by the vitamin treatment.

When the dry weight was expressed as a percentage of the fresh weight, it was revealed that the use of riboflavin at lower concentrations, alone or in combination with ascorbic acid, gave a higher value for root growth, indicative of a lower water content, in the vernalized series, and that the use of ascorbic acid, alone or in combination with riboflavin, at the lowest concentration gave a higher value for the shoots. No interesting results were obtained in the unvernalized series.

The investigation offers an opportunity to study the effects of ascorbic

Table 1. Data for the unvernalized (UV) and vernalized (V) series, expressed as percentages of growth of the respective controls.

Molar concentration	Length				Fresh weight				Dry weight			
	Root		Shoot		Root		Shoot		Root		Shoot	
	UV	V	UV	V	UV	V	UV	V	UV	V	UV	V
					Riboflavin							
10^{-3}	60	71	62	71	16	96	30	138	49	92	22	89
10^{-4}	99	113	64	181	118	166	120	376	110	219	113	291
10^{-5}	106	144	106	218	125	250	128	330	166	333	101	275
					Ascorbic acid							
10^{-3}	100	120	95	158	76	188	84	218	102	124	82	179
10^{-4}	108	120	128	188	131	187	143	334	164	170	126	231
10^{-5}	113	122	127	195	128	206	112	438	173	250	103	250
					Riboflavin plus ascorbic acid							
10^{-3}	38		35		51		5		5		5	
10^{-4}	83	120	99	170	128	70	110	258	164	128	125	215
10^{-5}	103	173	107	200	128	110	144	182	193	176	141	211