Table 1. Localization of I^{131} in tissues of *Rana grylio* tadpoles treated by ligation of bile duct (BD), ligation of esophagus in the region of the cardiac sphincter (Es), simultaneous ligation of both bile duct and esophagus (BD-Es), and ligation of cardiac and pyloric regions of stomach (St). The tadpoles were immersed in carrier free I^{131} solution (0.3 to 0.5 μc/ml) for 70 hours.

Group	Activity (%)*							
	Tail	Torso	Skin	Intestines and contents†	Stomach	Liver	Kidney	Bile
Normal	3.6	2.0	5.3	77.3		2.8	3.1	5.9
Ligated BD	1.3	2.2	9.1	74.7		3.4	2.8	6.5
Ligated Es	3.3	5.4	13.3	61.6		6.2	5.8	4.4
Ligated BD-Es	2.3	4.1	12.6	56.8		5.5	14.0	4.7
Normal	1.1	1.7	5.0	13.7	73.9	1.3	1.5	1.8
Ligated St	0.9	2.3	4.0	4.0	75.9	3.3	2.6	6.3

* Activity (%) = [(activity of I^{131}/100 mg) ÷ (sum of activity of I^{131}/100 mg in all tissues)] × 100. † The intestinal tract was emptied of its contents in some cases, and higher levels of iodide were found in the contents (*7*). The first four entries refer to the gastrointestinal tract. In the last two entries only the intestine is involved. For these two measurements the stomach and its contents were separated from the intestine and counted separately.

out on five animals from each group 2 days after they recovered from surgery.

The tadpoles were placed in a liter of tapwater containing between 150 to 250 μc of I^{131}. The animals were left in this I^{131} water for 70 hours and then dissected after being anesthetized with a 0.1 percent tricaine solution.

Skin (stripped down and inverted from a small ring around the oral cavity to the tip of the tail), tail, digestive tract, liver, bile, kidney, and torso were collected from each tadpole in each group of the experiments. The torso included the brain, eyes, gills, gonads, fat bodies, heart, and so on. The bile was collected from the gall bladder, and its weight was determined from the difference in the weight of liver before and after the gall bladder was emptied. The radioactivity of each tissue was measured with a scintillation counter. The activity per 100 mg of tissue was calculated for each tissue, and the average activity of the similar tissues from the five tadpoles in each group was computed. The total activity for the average whole animal was arrived at from the activity per 100 mg for each tissue and the percentage activity of each tissue computed from the former value (*6*).

The data are illustrated in Table 1. The intestine and contents show a high percentage of the total iodide accumulated by the rest of the tissues (*7*). The route by which I^{131} arrives in the digestive tract must be via the blood stream since its passage into the digestive tract is not changed when ligatures are placed on the esophagus and the common bile duct. The second experiment demonstrated that the stomach, isolated by ligatures or in the terminal dissection procedure, contained about 95 percent or almost all of the I^{131} previously found in the whole digestive tract. While no attempt is made to emphasize the statistical significance of the concentration of I^{131} in the tissues, the values were reproducible within about 15 percent and the greater effectiveness of the stomach in accumulating iodide was striking.

The accumulation of iodide in the stomach of the tadpole is probably incidental to its chloride pumping activity since the stomach forms hydrochloric acid and is reminiscent of the mamalian gastric mucosa (*6*). This pump may serve to concentrate, create a pool of, and recycle iodide. It thus may provide for the iodide needed during metamorphosis (*8*).

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2. W. W. Swingle, *Endocrinology* **2**, 283 (1918*a*); *J. Gen. Physiol.* **1**, 593 (1919).
3. We have confirmed Swingle's observation that both iodide- and iodine-treated flours induce metamorphosis in thyroidectomized tadpoles. We have also found that the addition of iodide (potassium iodide) or elemental iodine to flour causes the appearance of thyroxine in an aqueous extract of the treated flour. The presence of thyroxine was shown with paper chromatography using two different solvent systems—butanol and acetic acid, and butanol, dioxane, and ammonia. It is therefore questionable that this experiment proves metamorphosis in the absence of a source of thyroid hormone in *Rana grylio*.
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6. Several independent series of such experiments have confirmed the validity of these data.
7. Approximately 14 percent of iodide in the digestive tract may be associated with the wall of the system. But since the contents were expressed and the tract was not washed, this figure is probably high.
8. This study was supported by a grant from the National Institutes of Health.

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Sensory Deprivation: Its Effects on Human Learning

Abstract. The rote learning ability of human subjects under conditions of sensory deprivation for 48 hours was compared with results for a control group. The performance of the two groups was essentially the same. No significant facilitation or decrement in performance was noted, and in no instance were hallucinations, delusions, or other unusual phenomena reported.

Recent experimental studies (*1*) have indicated the variety of psychological effects which may occur in subjects under conditions of sensory deprivation, but few studies to date have been concerned with formal investigation of the effects of such conditions on learning in human beings.

In 1956 Vernon and Hoffman (*2*), reporting the effects on rote learning of confinement for 48 hours in a McGill type cubicle, concluded that learning was facilitated over the period of confinement, as indicated by a decrease in the number of trials required to meet the criterion. Such facilitation was not demonstrated in an extension of this study by Vernon and McGill (*3*) in 1957, as initially reported, but the conditions of the two studies were not exactly comparable. The investigation reported here is a further extension of the studies of Vernon and his associates (*2, 3*).

The paid, volunteer subjects were graduate and undergraduate students at the University of Miami. There were initially 18 subjects in the experimental group (six failed to complete the experiment) and 12 control subjects. The experimental cubicle, like that of Vernon and Hoffman (*2*) was 4 by 9 by 8 feet, lightproof and partially soundproof. It contained only a cot, the speaker for presenting word lists, and a two-way intercommunication system. The door of the cubicle contained a small one-way screen for monitoring the subjects' behavior. A shielded 20-watt bulb in the ceiling provided diffuse low-level illumination, and a large fan in the ceiling provided ventilation as well as a constant masking noise. The subject lay on the cot; he wore opaque goggles which permitted him to see light but interfered with patterned vision. Cotton gloves and cardboard tubes that extended from the elbows to below the finger tips minimized tactile stimulation.

Six word lists of equal difficulty, of 15 adjectives each [constructed from Hilgard's tables (*4*)], were presented

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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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