In January 1958 one of us (R.C.N.) discovered a paper coal in the high wall of a strip mine about ¾ mi north of Nyesville, near Rockville, Parke County, Indiana (SW¼SW¼ sec. 27, T.16N., R.7.W., Rockville Quadrangle). The upper 6 inches of the 18-inch coal bed is brown and leafy, like the yellowed pages of a book (Fig. 1, *C*). The lower 12 inches of the coal is solid, not papery. The paper coal layer is composed of matted plant cuticles and abundant spore exines embedded in vitrinitic attritus. Opaque attritus and anthraxylon are extremely sparse. The flexible aspect is most evident at the outcrop, where weathering has removed much of the interstitial vitrinite. An unusual sporelike body, named *Torispora* by Balme (*4*) and called *Bicoloria* by Horst (*5*), has been observed in abundance in the Indiana paper coal (Fig. 1, *D*).

The exact stratigraphic position of the Indiana paper coal has not been determined. Spore analyses of the paper coal and of other coals exposed in the general vicinity are being undertaken to aid in the stratigraphic interpretations. The coal mined at this locality, about 12 feet below the paper coal, has yielded a spore assemblage which indicates that it is in the Brazil formation (Upper Pottsville).

The cuticles which give the papery aspect to the coal are remains of small stems and leaves. Agitation in water, hand-picking, and treatment with Schultze's reagent and 12 percent potassium hydroxide facilitate separation of individual membranes of cuticle. Examples of isolated cuticles are shown in Fig. 1, *E* and *F*. Pinnules, pinnae, and rachides of ancient fernlike foliage, which must have grown in profusion in the area of coal deposition, are represented. The pinnules and pinnae resemble *Sphenopteris bradfordii* Arnold, a species of lyginopterid pteridosperm described by Arnold (*6*) from the Michigan Coal Basin. Arnold states that *S. bradfordii* may be identical with *S. marrati* Kidston. Sporangia, first noticed in thin sections and later isolated by hand-picking, consist of an outer layer of *Torispora* and a central mass of compressed, thin-coated spores. No seeds have been found, and no sporangia have been observed attached to cuticles.

The occurrence of this unusal paper coal can be attributed to three factors: (i) the foliage contributing to the paper coal was thoroughly cutinized; (ii) the environmental conditions were conducive to the preservation of these masses of cuticle; and (iii) post-diagenetic oxidation and mechanical removal of the vitrinitic attritus left almost pure cuticle.

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7. James M. Schopf (U.S. Geological Survey, Columbus, Ohio) graciously supplied us with a sample of Russian paper coal.
8. Publication of this article was authorized by the state geologist, Indiana Department of Conservation, Geological Survey.

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Pattern of Adaptive Control of Levels of Rat Liver Tryptophan Transaminase

Abstract. The dual control by substrate and hormone of the level of a third adaptive enzyme in animals is described. Injections of hydrocortisone or the substrate tryptophan increased the level of the liver tryptophan-α-ketoglutarate transaminase of intact rats within 5 hours. In adrenalectomized rats this enzyme level was increased by hydrocortisone alone, but substrate induction could be demonstrated only if these animals were treated at the same time with hydrocortisone.

The level of tryptophan-α-ketoglutarate transaminase in liver is approximately doubled after hydrocortisone treatment of rats (*1*). The levels reported here, determined 5 hours after treatment of intact or adrenalectomized albino rats of either sex with hydrocortisone or with the substrate tryptophan, showed that this is a new example of substrate and hormonal induction (adaptation) of an enzyme in animals, and one whose pattern of control is like that of tyrosine transaminase (*2*).

The enzyme was assayed by a specific spectrophotometric method (*3*) in freshly prepared liver homogenates of individual animals. The mean levels found in the different groups of rats (Table 1) indicate that a significant increase in tryptophan transaminase activity occurs in the intact rat after treatment with tryptophan and that a greater increase occurs after treatment with hydrocortisone.

In order to determine whether induction of the enzyme by the substrate can take place in the absence of adrenal cortical activity, adrenalectomized rats were studied 4 days after operation. After removal of the adrenals, the basal level of tryptophan transaminase fell somewhat below its level in intact animals. Injection of tryptophan produced a small rise in enzyme activity which was not statistically significant. The same or no response was produced by injections of D-tryptophan and the four analogs of tryptophan, α-methyl-DL-tryptophan, 5-methyl-DL-tryptophan, 6-methyl-DL-tryptophan, and DL-tryptazan. However, hydrocortisone treatment of the adrenalectomized rats still produced a significant (62 percent) increase in activity above the basal level. When L-tryptophan and hydrocortisone were given simultaneously to the adrenalectomized rats, the activity increased 167 percent above that of the adrenalectomized controls.

These results indicated that hydrocortisone is a stimulus sufficient to increase the enzyme activity in both the intact and adrenalectomized animals. On the other hand, the response to tryptophan found in intact animals was almost completely abolished by adrenalectomy. The potentiating effect of tryptophan on the enzyme level in the hydrocortisone treated, adrenalectomized animals indicated that there is a specific substrate-inducing effect, but only in the presence of adrenal cortical hormones. This occurred when the hormone was either released by the stress of substrate injection in the intact animals or when it was administered to the adrenalectomized animals.

The adaptive increase of this enzyme which is produced by corticoid stimulation alone, but by the substrate only in corticoid-treated animals, is identical

Table 1. Induction of liver tryptophan-α-ketoglutarate transaminase of intact and adrenalectomized rats.

Treatment	No. of animals	Mean activity of enzyme*	Change from controls	
			Percentage	*P*
		Intact rats		
Control	8	14.2 ± 4.38		
L-Tryptophan (0.5 g/kg)	4	21.0 ± 5.2	+ 50	< .02
Hydrocortisone (30 mg/kg)	6	37.0 ± 7.46	+ 161	< .01
		Adrenalectomized rats		
Control	4	10.6 ± 2.6		
L-Tryptophan (0.5 g/kg)	4	12.3 ± 2.8	+ 16	0.40
Hydrocortisone (15 mg/kg)	4	17.2 ± 1.8	+ 62	< .01
L-Tryptophan (0.5 g/kg) plus hydrocortisone (15 mg/kg)	4	28.3 ± 6.2	+ 167	< .01

* Activity is expressed as micromoles of indolylpyruvate formed per hour per gram of dry liver plus or minus standard deviation.

with the pattern of control established for the somewhat larger adaptive changes of the tyrosine-α-ketoglutarate transaminase (*2*). A corticoid-induced "metabolic state" (*4*), perhaps the basis for the "permissive" action of cortisone, is considered to be required for these two adaptive responses to the substrate stimuli. In contrast, the tryptophan pyrrolase (peroxidase-oxidase) level is also increased by corticoids, but the substrate is a sufficient stimulus by itself to adaptively increase this enzyme level (*5, 6*).

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Growth of Body Weight and Manipulation of Food Motivation

Abstract. Consideration was given to the possible use of individual growth curves to estimate *ad libitum*–feeding weights as part of technique for producing specified degrees of food deprivation. In heterozygous animals, this possibility was found to be feasible but limited by the occurrence of discontinuous growth functions.

In experiments said to deal with "motivation" for food or requiring "hungry" animals as part of the procedure—for example, to maintain operant responding with food reinforcement—some type of operational specification of food deprivation must be selected. A common technique for manipulating this variable is rhythm feeding, where animals are allowed to eat *ad libitum* for a fixed time interval *T* every *H* hours. In Fig. 1 (top), sample data obtained from 12½-month-old, random-bred, male Wistar albino rats show some effects of this technique on body weight when the values of *T* and *H* are, respectively, 1 and 23 hours. The daily weight immediately before feeding is expressed as percentage of *ad lib.*–feeding weight, where this base value is the rat's average weight for the 10 days of continuous feeding immediately preceding the start of the rhythm schedule (*1*).

Body weights decrease over successive days of the procedure, and the extent of the decline differs among individual rats (*2*). This suggests that, if one wishes to produce a constant degree of deprivation from rat to rat, a better technique may be deliberate reduction of body weight to a specified percentage of the *ad lib.*–feeding weight. However, *ad lib.*–feeding weight changes with age, and it is frequently necessary to initiate relatively prolonged studies with rats that are still growing. Therefore, in attempting to hold such a percentage fairly constant with the passage of time, one might wish to recompute this weight at regular intervals, using the changing base weights. But once a deprivation procedure is launched, how are we to know the weights that would have prevailed with increases in age, had the animal been permitted to feed freely?

It seemed to us that one answer lay in the *ad lib.*–feeding weights to be *expected* in an animal at various ages. These might be determined by extrapolation from an appropriate equation fitted to some of the animal's prior age-weight data. To examine the feasibility of this notion, we maintained daily age-weight records for rats (all males) feeding *ad libitum* in our colony areas, and for each animal, individual weekly mean weights were computed for successive weeks of age. Plots of typical individual growth data, treated in this manner, are presented for heterozygous males of the Charles River CD strain (*3*).

The lower plot of Fig. 1 shows that satisfactory prediction of *ad lib.*–feeding weight is possible. The smooth curve drawn through the data points is for the equation

$$y = -9.82 + 34.77x - 0.56x^2$$

fitted by the method of averages to the initial data, which are shown as filled circles. Weight values obtained later, shown as open circles, are in fair agreement with the extrapolated portion of the curve. The other curve, labeled *D*, is drawn through the average weekly weights at which this rat might have been maintained in order to keep it at 80 percent of his predicted *ad lib.*–feeding weight.

Continuous functions prevailing over the age range reported here were found to be rare. The bulk of the individual growth curves we obtained appear to be discontinuous functions of the type seen in Fig. 2. The first segment is negatively accelerated. It may be a parabola, as in Fig. 1, but it may be a function of other forms, such as

$$y = c - ae^{-bx}$$

and (*4*)

$$\log y = a - b(1/x)$$

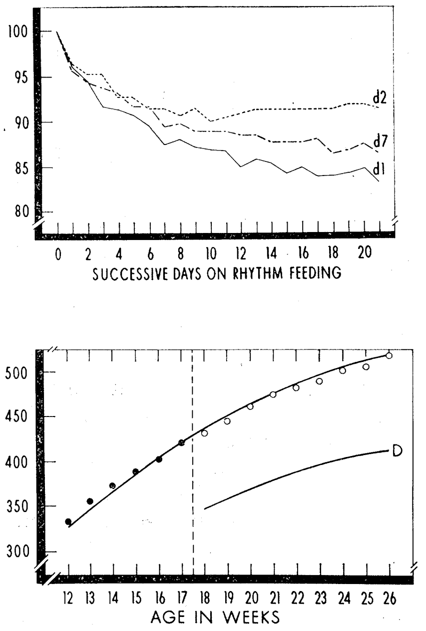

Fig. 1. (Top) Percentage *ad libitum*–feeding weight before eating as a function of successive days on a 23-hour feeding rhythm. Data from male Wistar rats. (Bottom) Individual weekly mean body weight in grams as a function of age in weeks for a male CD rat.

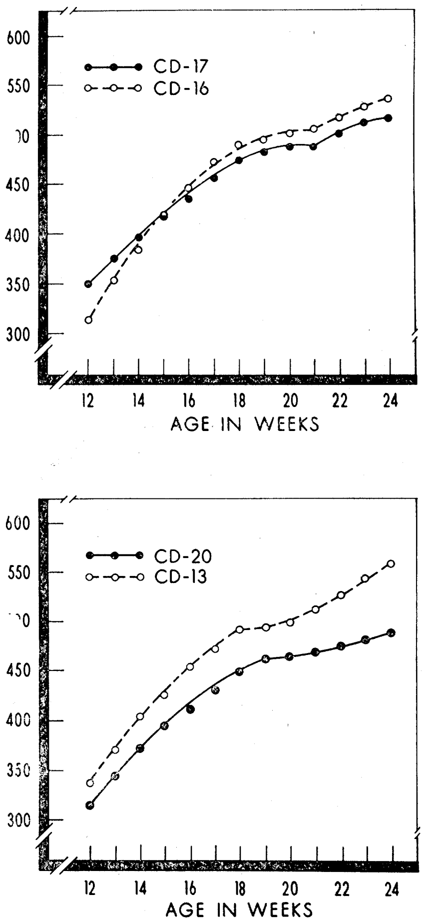

Fig. 2. Individual weekly mean body weight in grams as a function of age in weeks. Data from male CD rats.