that the shift in threshold of response to irradiation was of a stable nature under dark-adapted conditions and remained constant after the final irradiation at 200 r. The threshold was determined at irregular intervals on some preparations for as many as 6 hours with no apparent return to normalcy.

Light-adaptation apparently serves to cancel the effects of irradiation on the system when the receptor is once more dark-adapted and the threshold is again measured (Fig. 1, bottom). The disparity between this sensitivity level and the terminal sensitivity of the controls is no more than might be attributed to pathological decay of the system. A similar control point may be extrapolated from the data by extension of the curve for an equivalent length of time. On this basis we may tentatively place the locus of effect in the photochemical system.

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Paper Coal in Indiana

Abstract. The foliated, papery texture of the upper third of an 18-inch coal seam in a strip mine near Rockville, Indiana, is attributable to matted plant cuticle. The cuticles of pinnules, pinnae, and rachides resemble *Sphenopteris bradfordii* Arnold and thus differ from the lycopsid stem cuticles of the Russian paper coal.

In 1860 Auerbach and Trautschold (*1*) reported the occurrence of an unusual type of coal in the Moscow Basin of central Russia. This unique *Papierkohle,* as they called it, has been the subject of several reports and numerous discussions by geologists and botanists since then. The plant cuticles which make up the Russian paper coal are the remains of twigs of arborescent lycopods, although their specific botanical affinity has been the subject of considerable controversy. Auerbach and Trautschold (*1*) named the cuticles *Lepidodendron tenerrimum.* Walton (*2*) assigned them to the genus *Bothrodendron,* Bode (*3*) to *Porodendron,* a genus belonging to the eligulate Lycopodiales. Bode distinguished two species, *Porodendron lepidodendroides* and *P. pinakodendroides.* Figure 1, *A* and *B,* shows cuticles that occur in the Russian *Papierkohle.*

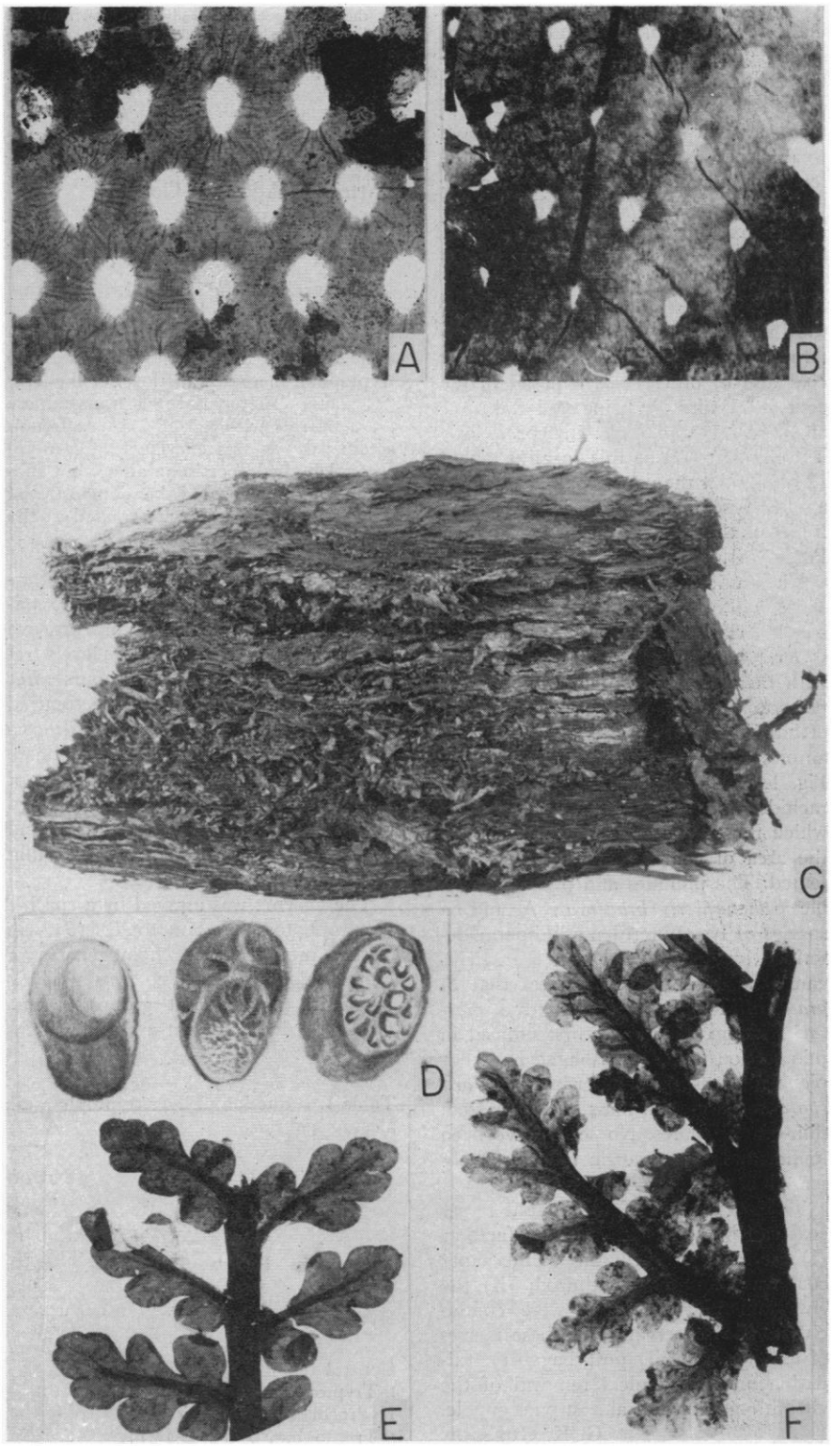

Fig. 1. *A, B,* Cuticle from the Russian paper coal (*7*) (about × 2). *C,* Block of Indiana paper coal (about × ¼). *D,* Drawings of Torispora specimens (about × 250). *E, F,* Parts of pinnae from Indiana paper coal (about × 2).

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 unusual 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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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.