excited state. Similarly, reaction (4), proceeding by a chain mechanism involving oxygen atoms, is known to give rise to excited CO_2 (*4, 10, 11, 12, 13*). The addition mechanism is therefore consistent with the formation of HCO and CO_2 in electronically excited states.

In the peroxide mechanism the following steps are among those that may be expected to occur:

$$
\begin{array}{lll}
(1) & C_2H_2 + O_2 & \rightarrow \\
(2) & H{-}C{\equiv}C{-} + O_2 & \rightarrow \\
(3) & H{-}C{\equiv}C{-}O{-}O{-} + C_2H_2 & \rightarrow \\
(4) & H{-}C{\equiv}C{-}O{-}O{-}H & \rightarrow \\
(5) & H{-}C{=}C{=}O & \rightarrow \\
(6) & H{-}C{\equiv}C{-} + O_2 & \rightarrow \\
(7) & 2CH & \rightarrow
\end{array}
$$

Reactions (4), (5), (6), and (7) would seem to be the most likely reactions producing OH, CH, and C_2, and reaction (7), being a radical-radical reaction, is probably very unimportant. Reactions (4), (5), and (6) are all endothermic; they are therefore slow, and there is a negligible possibility that they will produce OH, CH, and C_2 in electronically excited states.

In order to account for the spectroscopic result that OH, CH, and C_2 are electronically excited in the flame, it therefore seems necessary to assume, as was done in the case of the carbon-monoxide oxidation (*14*), that transfers of electronic energy occur:

$$
\left\{\begin{matrix} CO_2{}^* \\ HCO^* \end{matrix}\right\} + \left\{\begin{matrix} C_2 \\ OH \\ CH \end{matrix}\right\} \rightarrow \left\{\begin{matrix} CO_2 \\ HCO \end{matrix}\right\} + \left\{\begin{matrix} C_2{}^* \\ OH^* \\ CH^* \end{matrix}\right\}
$$

Our interpretation of the spectroscopic results, in terms of the kinetic mechanisms, may be summarized as follows: Reaction proceeds mainly by the exothermic addition mechanism and, of the HCO radicals and CO_2 molecules produced, very small fractions are electronically excited. At the same time very small amounts of C_2, CH, and OH are produced by the peroxide mechanism. In order to explain the fact that in hot flames there is more radiation from C_2, CH, and OH than from HCO, we suppose that HCO* and CO_2* have long radiative lives and may transfer energy to C_2, CH, and OH on collision. This situation is similar to that in the carbon-monoxide flame, in which much of the radiation is due to O_2 (Schumann-Runge bands) (*5, 8, 9*) in spite of the fact that it is the CO_2* molecule that is formed directly.

It is clear that most of the HCO* and CO_2* will only transfer energy to C_2, CH, and OH provided the latter are present at sufficiently high concentrations, i.e., provided the flame is hot. If the flame is cooled, by the addition of CO_2 or by other means, the concentrations of the endothermically produced C_2, CH, and OH will be reduced markedly, and there will be much less energy transfer from HCO* and CO_2*. The enhancement of the hydrocarbon flame bands under these conditions is thus readily explained. The fact that the C_2 bands are most sharply affected by change in temperature finds a ready explanation in terms of our mechanism, for C_2 is produced by the most endothermic reaction, which is therefore to be expected to have the highest temperature coefficient.

We are continuing a variety of experimental and theoretical studies in the hope that more definite evidence may be found concerning the identification of the emitter of the hydrocarbon flame bands and the details of the kinetic mechanisms involved in hydrocarbon combustion. We also hope to publish in the near future a more detailed discussion of the results reported here.

$H{-}C{\equiv}C{-} + HO_2 - \sim 60$ kcal
$H{-}C{\equiv}C{-}O{-}O{-} + \sim 50$ kcal
$H{-}C{\equiv}C{-}O{-}O{-}H + C_2H - \sim 10$ kcal
$H{-}C{\equiv}C{=}O + OH - \sim 30$ kcal
$CH + CO - \sim 75$ kcal
$HO_2 + C_2 - \sim 120$ kcal
$C_2 + H_2 + \sim 30$ kcal

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The Function of the Symbiotic Yeasts of Two Insect Species, *Lasioderma serricorne* F. and *Stegobium* (*Sitodrepa*) *paniceum* L.

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It was shown by Fraenkel and Blewett (*3*), and Blewett and Fraenkel (*1*), that the symbiotic yeasts, which occur intracellularly in mycetomes situated at the junction of the fore- and mid-gut of two species of anobiid beetles, *Lasioderma serricorne* and *Stegobium paniceum*, supply vitamins of the B group in significant amounts and make it possible for their hosts to subsist on foods very low in vitamins of that group. Indeed, the larvae grew normally, or almost so, on synthetic diets which were entirely lacking in such important factors as thiamin, riboflavin, nicotinic acid, pyridoxin, or pantothenic acid. When these yeasts were eliminated from the hosts

TABLE 1

GROWTH OF LARVAE OF *Lasioderma* AND *Stegobium* IN THE PRESENCE AND ABSENCE OF THEIR OWN SYMBIONTS, IN THE PRESENCE OF SYMBIONTS FROM THE OTHER HOST, AND IN THE PRESENCE OR ABSENCE OF VITAMINS OF THE B COMPLEX*

	Lasioderma sericorne						*Stegobium paniceum*					
	Normal		Without symbionts		Sterilized, reinfested with *Stegobium* yeasts		Normal		Without symbionts		Sterilized, reinfested with *Lasioderma* yeasts	
	No.	Period, days	No.	Period, days	No.	Period, days	No.	Period, days	No.	Period, days	No.	Period, days
Basic diet	18	26–35	16	29–39	14	27–40	16	42–55	13	46–57	11	45–60
No thiamin	8	36–43	7	35–47	2	40–43	0	.....	0	.....	7	49–85
No riboflavin	16	26–38	0	.....	6	33–41	13	43–63	0	.....	7	42–62
No nicotinic acid	13	30–36	0	.....	10	34–47	14	44–59	0	.....	8	47–68
No pyridoxin	13	33–42	0	.....	0	.....	12	45–62	0	.....	11	49–68
No pantothenic acid	15	28–37	0	.....	3	33–41	9	44–62	0	.....	7	47–82
No choline	16	29–43	0	.....	9	34–45	13	43–60	9	44–66	7	46–62
No inositol	15	30–33	15	27–42	9	27–47	14	42–57	13	46–62	11	42–69
No biotin	10	42–52	8	46–55	3	42–46	6	57–105	0	.....	6	60–83
No pteroylglutamic acid	15	29–38	5	39–48	8	34–44	9	46–60	0	.....	9	46–79
Wheat bran + 5% yeast	20	24–28	17	27–30	14	25–27	19	30–32	..	.....	..	.....

* Basic diet consisted of casein 20, glucose 80, cholesterol 1, and McCollum's salt mixture 2, with addition of the following B-complex vitamins (expressed in μg/g of diet) : thiamin 25, riboflavin 12.5, nicotinic acid 25, pyridoxin 12.5, pantothenic acid 25, choline 500, inositol 250, pteroylglutamic acid 2.5, and biotin 0.1. Total number of adults, out of 20, and duration of larval and pupal periods are given. Tests run at 27° C and 70% relative humidity.

by a simple surface sterilization of the eggs, growth in the resulting larvae ceased entirely in the absence of any of these vitamins. These experiments have now been repeated with similar results and extended to diets which were lacking also in either biotin or pteroylglutamic acid (Table 1). There can be no doubt that biotin and pteroylglutamic acid are also supplied by the yeasts in significant amounts.

It has proved possible to cultivate these symbiotic yeasts outside the bodies in Hansen's solution, those from *Lasioderma* responding more favorably to cultivation than those from *Stegobium*. The yeasts from the two species are strikingly different in shape, appearance, and mode of budding, both *in situ* and in culture (Figs. 1, 2). They have so far been classified only very imperfectly as belonging to the genus *Saccharomyces*. Buchner (*2*) named the symbionts of *Stegobium* as *Saccharomyces anobii*. Sporulation has never been observed, but budding frequently occurs in larvae and pupae, though rarely in adults. It was noted that in the pupa of *Lasioderma*, in contrast with the larval and adult stages, yeast cells

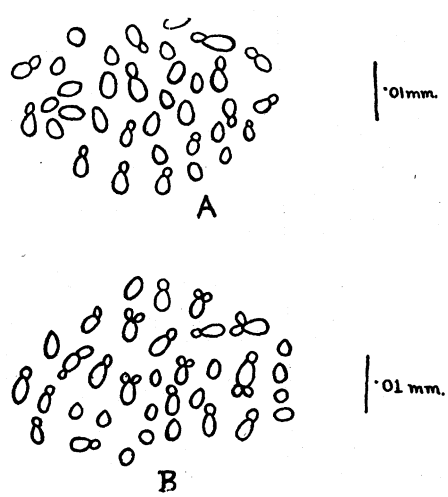

FIG. 1. Yeastlike symbionts of *Lasioderma sericorne*: *A*, mycetomic yeast of the larvae; *B*, mycetomic yeast of the pupa.

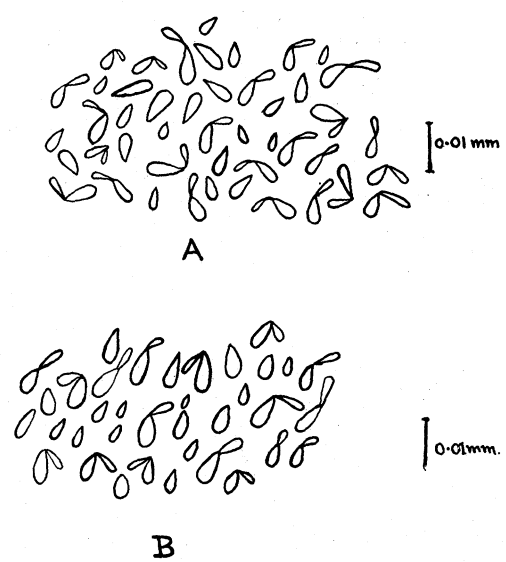

FIG. 2. Yeastlike symbionts of *Stegobium paniceum*: *A*, mycetomic yeast of the larva; *B*, yeast cultivated in Hansen's solution.

frequently show two buds (*B*, Fig. 1). The yeasts do not seem to ferment glucose with development of carbon dioxide.

Reimplanted into "sterilized" insects from culture, the yeast cells reestablished themselves normally in the mycetomes. This reinhabitation was achieved by various methods, of which smearing the surface of eggs or feeding sterilized insects with yeast culture proved the most successful. Indeed, yeast from *Lasioderma* settled apparently normally in *Stegobium*, and from *Stegobium* in *Lasioderma*, without altering their characteristic appearance and physiological function. It is evident, from a comparison of the results in Table 1, that with *Lasioderma* the effect of yeast from *Lasioderma* is, in most cases of individual vitamin deficiencies, superior to that of yeasts from *Stegobium*, and the same holds, though to a lesser degree, for yeasts from *Stegobium, mutatis mutandis*. Altogether, it seems that yeasts from *Lasioderma* may contain larger amounts of certain factors, especially thiaman, pyridoxin, pantothenic acid, biotin, and pteroylglutamic acid, than those from *Stegobium*. Inositol is not required by either species, and *Stegobium* is little affected by a deficiency in choline.

It is shown in Table 1 that "sterilized" insects, in the presence of all 9 vitamins, grow about as well as normal insects. In the absence of the pure vitamins, normal growth ensues with the addition of either 2.5% dried brewers' yeast, or 2.5% dried *Lasioderma* yeast from pure culture. This again clearly shows *Lasioderma* yeast to be a good source of all the known vitamins of the B complex.

TABLE 2

GROWTH OF LARVAE OF *Lasioderma* AND *Stegobium* ON THE BASIC DIET (Table 1) IN THE PRESENCE AND ABSENCE OF SYMBIONTS AND WITH AND WITHOUT THE ADDITION OF CHOLESTEROL

	Lasioderma				*Stegobium*			
	With symbionts		Without symbionts		With symbionts		Without symbionts	
	No.	Period, days	No.	Period, days	No.	Period, days	No.	Period, days
With cholesterol	15	30–46	15	30–36	13	38–57	14	41–62
Without cholesterol	14	33–43	7	33–41	7	35–47	2	50–62
Wheat bran + 5% yeast	19	25–29	17	25–34	..	.....	..	.....

The yeasts in our two species also serve for their hosts as sources of sterols. It has been shown for many insects, including *Lasioderma* and *Stegobium* (*4*), that a sterol is a necessary constituent of the diet. Omission of cholesterol from the synthetic diet has little effect on the normal larva of *Lasioderma* and some effect on the normal larva of *Stegobium*. In the "sterilized" larvae, however, the sterol-free diet becomes relatively more inferior (Table 2).

A full report of these observations will appear elsewhere.

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Some New Plant-Growth Inhibitors[1]

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It is intended in this report to describe briefly the inhibitory action on the growth of healthy and tumor tissue of higher plants of certain compounds that have shown promise as chemotherapeutic agents in the treatment of cancer (*2–5*). The growth-inhibiting action of 57 different compounds has been assessed in this laboratory. As test object in the preliminary survey, small (5-mm) fragments of stem tissue of the garden chrysanthemum var. Golden Treasure were employed. These were more uniform in their response than were the carrot fragments used in an earlier study (*1*). The fragments were inoculated with crown-gall bacteria (strain B.P.) and cultured for 3 days *in vitro* in small tubes containing 3 ml sucrose-mineral agar. An aqueous solution of the substance to be tested (conc, 1 mg/ml) was then applied to the surface of the developing tumor. Inhibition of tumor growth generally became evident 3 days later. Seven sulfonamides, 6 antibiotic substances, 9 plant-growth hormones, and 4 purine and pyrimidine derivatives proved inactive. The most active growth inhibitors belonged to the group of analogues of pteroylglutamic acid. Certain nitrogen mustards, 8-azaguanine (guanazolo), and cortisone also exerted an inhibitory action on the growth of the crown-gall tumors.

The action of these compounds on tumor and healthy plant tissue was compared in a series of *in vitro* tests. Various concentrations of the substances to be tested were added to suitable nutrient media in which fragments of bacteria-free crown-gall tumor tissue of sunflower, excised tomato roots, or excised sunflower embryos were cultured aseptically. The tissue fragments were weighed at the beginning and end of the 4-week culture period, and their percentage weight increases were calculated.

The most powerful growth-inhibiting action was possessed by 4-amino-N^{10}-methylpteroylglutamic acid, (A-methopterin), 4-amino-9-methyl P.G.A., (A-ninopterin), and 4-amino-9, N^{10}-dimethyl P.G.A., (A-denopterin). These compounds completely suppressed the growth of excised tomato roots in a concentration of 1 μg/litre. The growth of sunflower tumor tissue and embryos was only slightly inhibited at this low concentration but was almost completely inhibited by concentrations of 10–100

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