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TRAUMATIC ACID AND THIAMIN AS GROWTH FACTORS FOR
ALGAE¹

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Bottomley and, especially, Ashby² showed that *Lemna* develops well in a purely inorganic medium, although it thrives better if some organic matter, such as a soil extract, is added. The addition of soil extract and other chemically ill-defined organic matters³ to the culture medium of algae is a general practice.⁴ Since the chemistry of many plant hormones has become known in recent years it seemed of interest to see in which respect they affect the growth of algae. Yin⁵ studied the effect of auxin on *Chlorella* and found an inhibition of the multiplication but an increase of the individual cell size. Pratt,⁶ however, found just the reverse, an increase in cell number and no increase in cell size. Recently English, Bonner and Haagen-Smit⁷ isolated and synthesized traumatic acid (1-decene-1, 10 dicarboxylic acid), a wound hormone of plants, which causes considerable proliferation and elongation of parenchymatous tissues (bean pods and potato tubers). On the assumption that this substance might exhibit similar properties on plant cells in general, it was added to the sterile cultures of unicellular algae⁸ in order to determine whether it promotes the growth. Traumatic acid indeed proved to be highly effective in promoting multiplication of the culture, as is shown in the table for *Scenedesmus obliquus*, *Sc. bijugatus*, *Sc. brasiliensis* and *Palmellococcus miniatus*. Similar results were obtained with *Coccomyxa subellipsoidea* forma *putridena*, *Kirchneriella spec.?*, *Coelastrum proboscideum* var. *gracilis* and *Stichococcus bacillaris*.⁹

Thiamin was recognized as a growth factor for fungi by Schopfer¹⁰ and later on also as a growth factor for higher plants.¹¹ Thiamin was found to be ineffective, or at least far less effective than traumatic acid, when added to cultures (in basic inorganic medium) of the previously mentioned algae. It proved, however, to be decidedly effective in promoting the growth of *Sphaerella lacustris* (*Haematococcus pluvialis*).¹² Traumatic acid also af-

fects the growth of *Sphaerella lacustris* but to a lesser extent than vitamin B₁.

Adenine has lately been shown to be active as a factor for leaf growth.¹³ No algae have been found so far that respond markedly to it.

The above-mentioned experiments show that both traumatic acid and thiamin are growth factors for algae.

MULTIPLICATION OF ALGAE UNDER STERILE CULTURE CONDITIONS, AS MEASURED BY PHOTOELECTRIC TURBIDITY MEASUREMENTS

	ADDED TO THE BASIC INORGANIC MEDIUM: ⁸							
	TRAUMATIC ACID			VITAMIN B ₁		ADE- TRAUM. + NINE B ₁ + ADEN.		NO ADDI- TIONS
	5000 γ/1	1000 γ/1	100 γ/1	1000 γ/1	100 γ/1	1000 γ/1	100γ/1 BACH	
<i>Scenedesmus obliquus</i>	62.0	41.4	26.2	..	..	..	..	19.4
(6 days after inoculation; pH 6.6)	68.9	45.1	26.9	..	..	..	..	22.2
<i>Sc. bijugatus</i>	99.2	84.8	56.2	..	..	..	..	49.2
(12 days after inoculation; pH 6.6)	93.0	80.6	52.2	..	..	..	..	47.6
<i>Sc. bijugatus</i>	...	94.4	40.6	24.0	37.3	31.1	43.2	22.6
(20 days after inoculation)								
<i>Sc. brasiliensis</i>	141.4	100.0	71.4	..	..	..	..	74.2
(12 days after inoculation; pH 6.6)	118.0	92.2	70.2	..	..	..	..	62.4
<i>Palmellococcus miniatus</i>	115.6	107.0	49.8	..	..	..	..	56.4
(12 days after inoculation; pH 6.6)	102.0	92.6	48.0	..	..	..	..	43.2
<i>Haematococcus pluvialis</i>	...	Fourth	No	Best	Second	No	Third	No
(ring on wall of tube esti- mated after 20 days)		growth	growth	growth	growth	growth	growth	growth

In a purely inorganic medium and under the conditions described here the algae probably produce¹⁴ a limited amount of the growth factors, but not sufficient to sustain a rapid growth.

¹ Work assisted by the Works Progress Administration (Official Project 65-1-07-98, Work Project N-11534).

² *Ann. Bot.*, **43**, 805-816 (1929).

³ E.g., *Am. Jour. Bot.*, **27**, 161 (1940).

⁴ Bold, Harold C., *Jour. Tenn. Acad. Sci.*, **12**, 205-212 (1936).

⁵ *Proc. Nat. Acad. Sci.*, **23**, 174-176 (1937).

⁶ *Am. Jour. Bot.*, **25**, 498-501 (1938).

⁷ *Science*, **90**, 329 (1939); the traumatic acid used in these experiments was obtained through courtesy of these authors.

⁸ The basic inorganic medium consisted of 1/8 Hoagland solution plus minor elements, with the exception of copper (*Univ. Cal., Coll. Agri. Cir.* **347**, 36-37, December (1938)). Glass-distilled water was used throughout. Agar was not used in the experiments described here because it was found to be an unsuitable medium for the demonstration of the action of organic growth factors. Inoculations were made by using 1 cc. of a cell

suspension. The cultures were in culture tubes (15 cc. of medium) in indirect daylight in an air-conditioned greenhouse (constant temperature, 26°C.).

⁹ These algae were obtained through courtesy of Dr. C. B. van Niel, Pacific Grove, Calif.

¹⁰ Schopfer, W. H., *Compt. Rend. Soc. Phys. Hist. Nat. Geneve*, **51**, 26 (1934).

¹¹ Kögl, F., and Haagen-Smit, A. J., *Zeit. Physiol. Chem.*, **243**, 209-226 (1936); Bonner, J., *Science*, **85**, 183-184 (1937); Robbins, W., and Bartley, M., *Ibid.*, **85**, 246 (1937).

¹² Obtained through courtesy of Dr. Florence Meier Chase, Smithsonian Institution.

¹³ Bonner, D. M., and Haagen-Smit, A. J., *Proc. Nat. Acad. Sci.*, **25**, 184-188 (1939).

¹⁴ The presence of vitamin B₁ in marine algae was reported by E. R. Norris, M. K. Simeon and H. B. Williams, *Jour. Nutrition*, **13**, 425-433 (1937).

SOME TRABECULATE CODIUMS (INCLUDING TWO NEW SPECIES)

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Trabeculae ("Balken," "Cordons cellulosiques," etc.), as applying to protrusions from the "wall" into the cavity of a septate or unseptate coenocyte, occur particularly in species of *Caulerpa* and *Dictyosphaeria*, both genera of the general group of the Siphonales, to which the genus *Codium* also belongs. Thus far they have not been described for any of the numerous species of *Codium*. In a few species of *Codium*, however, various types of projections have been noticed extending from the inner portions of the apical membrane of the utricles into the general cavity of the coenocyte. O. C. Schmidt ("Biblioth. Bot.," Heft 91, p. 27, figure 7 (1923)) shows tips of utricles of his extended and probably composite *Codium adhaerens* which have the inner portions of the membrane alveolate, with inwardly extending anastomosing plates (as shown in section in the lowermost tip under his figure 7). Such sculpturing of the inner layers of the apical membrane has been seen by me in a number of species of both *Tylecodiums* and *Schizocodiums*, often sufficiently constant to seem characteristic of the particular species. M. A. Howe (in Britton and Millspaugh, "The Bahama Flora," p. 617 (1920)) has described a variety, or form, *cribosum*, of *Codium intertextum* Collins and Hervey, but this alveolation seems to be really a character of the mature utricles of this species (which is included under the extensive aggregate of *Codium adhaerens* by O. C. Schmidt). These alveolar inner surfaces of the apical membrane have been little noticed and often are not to be seen except on careful illumination. From the surface, under proper lighting of fresh utricles or those swollen to nor-