

Letters to the Editor

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Bast-Sap in Plants

IN 1858 Th. Hartig directed attention to the fact that many trees yield drops of sap when their bark is punctured in summer and autumn. This sap issuing from the inner layers of the bast was said to include small quantities of nitrogenous substances with large quantities of various kinds of sugar. Obviously its motion and constitution might yield some information on the transport problem of organic substances. We found the most abundant flow when the puncture reaches the inner layers of the bast; deepening the puncture so as to reach the wood, causes the sap exuded to be instantly drawn in by the tensile water in the vessels. Hence the exuded sap is not driven out by root-pressure through the outer xylem. The exuding sap is transmitted by the sieve-tubes as we demonstrated by forcing a solution of potassium ferrocyanide into the puncture and afterwards tracing its path by means of ferric chloride.

In a stem of a young specimen of *Fraxinus excelsior* about 12 cm. in diameter all the seven or eight layers of soft bast transmitted the solution to some extent, while the inner layers transmitted it most readily. A pressure of 3 atm. drove the solution 3.5 cm. in 30 min. We have observed the flow of bast-sap in forty to fifty species of trees and in several herbaceous forms during June, July, August and September. All specimens of the same species in the same locality do not exude bast-sap simultaneously. The amounts exuded are variable. In active specimens the flow from a slit 1 mm. long continues for 30–45 min. and yields 0.1–0.2 c.c. Active flow from one puncture inhibits or reduces the flow from closely neighbouring punctures, and the amounts delivered from similar punctures at the same level, even when not influenced by neighbouring punctures, are not uniform.

Small quantities of proteins and glucose associated with considerable amounts of sucrose were found in the sap; the presence of tannin, an oxidase and a chromogen is also indicated. The sap is extruded by the turgor of a closed system in the bast (probably the sieve-tubes), and the flow only ceases when that pressure becomes negligible. Freezing point determinations give a measure of this pressure. Unexpectedly high pressures were observed ranging from 13 to 35 atm. The forces moving the sap through the bast and forcing it through the punctures are very high. Very different pressures have been observed in the same specimen on different occasions; but so far, it has always been found that the osmotic pressure of sap issuing from a higher level is greater than that coming from a lower one. Osmotic pressure gradients of 2.2–8.9 atm. per metre have been observed in the bast of *Fraxinus excelsior*.

Lateral motion is inconsiderable compared to longitudinal movement, hence from the amount exuded through a puncture of known size under the pressures available we obtain some idea of the ease with which the sap moves longitudinally in the bast. The gradient of pressure is presumably maintained by the production of carbohydrates in the leaves and

their removal by condensation into products of growth (activity of the cambium) and materials of storage (sucrose, starch, etc., deposited in the bast-parenchyma, starch-sheath, cortex and medullary rays).

The difference in osmotic pressure above and below in the intact plant is available for forcing the solvent, water, of the less concentrated solutions below into the wood, thus creating a mass-movement of the solution downwards through the bast. These and other observations seem to us to support Münch's theory of mass-movement of organic substances in the bast, and probably bring into line the results of Mason's and Maskell's investigations.

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Stability of the Liquid Carbon Dioxide in the Ocean

IN NATURE of July 2, p. 26, Dr. Wattenberg of Berlin presented some objections to my paper "On the Field of Stability of Liquid Carbon Dioxide in the Biosphere".¹

It is a pity that Dr. Wattenberg in formulating his criticism used, apparently, only the short notice of my paper which recently appeared in NATURE² and not the paper itself. Had he read my original paper he would have saved himself from misunderstanding of my point of view.

The water of the ocean, like the water of all the deep continental water-basins, is heterogeneous as to its baric properties, presenting a substance which cannot be reproduced by experiment since it has the properties of a specifically planetary phenomenon. In the ocean the water itself is subjected to pressures which can exceed 1000 atm./cm.³ and at the same time the dissolved gases in the same water (which are in an innate connexion with the troposphere) are subjected to pressures which can not exceed 1–2 atm./cm.³ In the thermodynamical conditions of the ocean's water all the carbon dioxide masses which are isolated (completely or partly) from the troposphere (that is, from the gases dissolved in the oceanic water), must exist in a special state of phases:

liquid CO₂ ⇌ gaseous CO₂,

because the temperatures and the pressure of seawater remain mostly below the critical point and above the critical pressure of carbon dioxide.

Marine organisms must have accommodated themselves throughout geological time to the specific state of carbon dioxide in the ocean. They have to obtain a special organisation in this respect.

I have indicated in my paper the following three examples among many of such accommodations:

1. The accommodation of plankton organisms in connexion with the low confines of their habitation.
2. The oxygen glands of deep-sea fishes in connexion with their respiration.

3. The conditions of life of micro-organisms in the bottom sediments of the ocean. The chemical processes in such sediments are regulated by micro-organisms. They are subject to changes under the influence of liquid carbonic dioxide, the possibility of existence of which in living environments cannot be denied.

The same peculiarities of carbon dioxide must influence many inorganic processes such as exhalations of gaseous carbonic dioxide in the gaseous and mineral springs on the sea-bottom.

The peculiar character of carbon dioxide in the ocean in comparison with its behaviour on the earth's surface must be taken into consideration in all conclusions concerning the state of the gaseous solutions in the ocean. There certainly must exist a lower limit than the gaseous solution of carbon dioxide in sea-water and therefore we must expect to find at greater depths only ions or hydrates of carbonic acids.

For further discussion on this subject reference must be made to my paper already cited. I have also discussed the subject in my lecture "Oceanography and Geochemistry" delivered in the Mineralogical Institute at Göttingen, which is to be published in the *Tschermaks Mineralog. u. Petrographische Mitteilungen*.

Further study in the same field of research has been made by Prof. V. Chlopin, who has published his results in the *Comptes Rendus* of the Academy of Sciences, Leningrad, mentioned before. Prof. V. G. Chlopin has shown that in the same conditions, which have been demonstrated by me for carbon dioxide in sea-water, the inert gases (argon, krypton, xenon) must give hydrates, which are soluble in sea-water. Apparently the geochemistry of the inert gases offers here a new and promising ground for research.

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¹ *C.R. Acad. Sci. Leningrad*, 289-295: 1931.

² *NATURE*, 129, 607, April 23, 1932.

Bead-Corona on Radio Antenna

DURING the period February-March 1932, of exceptionally dry atmospheric conditions, a curious high frequency - high tension - phenomenon was observed on several days on the antenna of the Hilversum (Holland) broadcasting station (λ = about 300 m., aerial power 15-20 kw.).

The aerial consists of five horizontal wires, strung between two metal masts sixty metres in height, and is connected at both sides to insulators fastened to two spreaders. There are five downleads, connected to the central part of the aerial wires.

On February 14, at 20.00, a corona was observed on the antenna, and this corona caused an acoustical effect such that the modulation of the emission could clearly be heard up to a distance of approximately 800 m. A reduction of the antenna power from 20 kw. to 12 kw. caused the phenomenon to disappear.

Again, on March 7, at 17.00, when the antenna power was raised from 7 kw. to 20 kw., the corona on the antenna reappeared. It consisted of slowly moving luminous spheres of about 10 cm. diameter. They first appeared at one end of an outer wire, they slowly moved, following the wires towards the downleads and disappeared at a distance of about 15 m. from their origin. Several of these luminous spheres were observed to occur simultaneously with a mutual distance of 0.5 m., so that the phenomenon made the impression of a string of beads, moving towards the centre with a speed of the order of 1 m./sec.

The phenomenon usually started at an outer wire, and when this was covered with beads over a length of about 15 m., also the second, the third and the fourth wire gradually developed the beads in a similar way. The colour of the beads varied from yellow to a light blue and pink. The sound emitted by this corona (corresponding to the modulation of the transmitter) was very distinct and could be heard up to a distance of 1-1.5 kilometres, so that a big crowd gathered round the gate of the station, listening in astonishment to the voice of a preacher, directly from the heavens.

The modulation was also plainly visible in the glittering of the emitted light. On that day again the phenomenon disappeared with the reduction of the antenna power from 20 kw. to about 10 kw. At 19.00 an increase of the aerial power caused the corona to reappear.

The same phenomenon was again observed on March 9, 10, 11, 12, and 13. Since March 16 the corona has not occurred.

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Influence of Impurities on the Transformation Point of Liquid Allotropic Modifications

RECENT investigations dealing with the properties of liquid nitrobenzene, in the neighbourhood of the melting point, are yielding discordant results. Wolfke and Mazur,¹ in a carefully purified specimen, observe discontinuities at 9.5° C.; this temperature, they suggest, represents the transformation point of two distinct modifications of liquid nitrobenzene. Stewart,² using X-rays, confirms the assumption. Massy, Warren, and Wolfenden,³ Newton Friend,⁴ and Piekara⁵ were unable to discover any discontinuities. The interesting question arises as to how far these discrepancies may be accounted for by assuming slight impurities to have been present in the samples used.

When two diluted solution phases co-exist, we have the well known equation

$$\frac{L}{S} dS = \frac{x_2 - x_1}{x_1} R S dx_1$$

where L stands for the heat of transformation from phase (1) to phase (2), R is the gas constant (both per gm. mol.), x_1 and x_2 are the molecular concentrations in phases (1) and (2), and S denotes the absolute temperature of transformation (see, for example, Van der Waals' "Lehrbuch der Thermodynamik", vol. 2, p. 80); the pressure is here assumed to remain constant. For the difference ΔS of the transformation points of the pure substance and that of the solution, we accordingly obtain

$$\Delta S = \frac{dS}{dx_1} x_1 = \frac{RS^2}{L} (x_2 - x_1).$$

That the allotropic modifications have unequal dissolving power is a common occurrence; the dielectric constant, which influences the dissolving power, increases nearly fourfold when we pass from nitrobenzene II to nitrobenzene I; thus x_1 and x_2 may be assumed unequal. Since the heat of transformation L for nitrobenzene ((1) \rightarrow (2)) is exceptionally small (0.14 cal. per gm.), the effect of slight impurities may be to depress the transformation point below the freezing point; the liquid phase, nitrobenzene II, permanent below 9.5° C., would then disappear.