THE ASCENT OF SAP IN PLANTS.

A NEW AND INGENIOUS THEORY.

BY DR. GUSTAV GLOCK.

WHEN the chemist cannot determine the atomic structure of a new compound by analysis, he attempts to determine it by synthesis.

The mechanism by which sap is moved in plants has not yet been revealed by anatomical study, but we may, perhaps, discover it by constructing an artificial plant capable of performing at least this single function with the aid of the natural forces which are at the disposal of the real plant. At least two such natural sources of energy exist: variations in the temperature, and variations in the pressure, of the atmosphere.

The scheme of the artificial plant is shown in the illustration. It comprises an indefinite number of open vessels *b*, alternating in a vertical series, with closed vessels *a*. In the bottom of each closed vessel *a* is a small orifice *m*, which is covered by a valve opening upward and communicates with a tube *c* extending nearly to the bottom of the open vessel *b* beneath. The top of each closed vessel *a* is pierced by a tube *d* which extends downward nearly to the bottom of that vessel and terminates in a funnel-shaped expansion containing a valve *n* which opens upward. The tube *d* extends upward beyond the vessel *b*, above, and its curved end opens over the open mouth of that vessel.

Now let us fill the lowest of the open vessels *b* with water, and see what will happen. As the temperature falls, at night, the air in the closed vessel *a* next above, contracts, and "draws" water from the vessel *b* below, in which operation the valve *m* is open and the valve *n* is closed. As the temperature rises, in the morning, the air in *a* expands and forces water into the vessel *b* above, the valve *m* closing and the valve *n* opening automatically. This cycle of operations is repeated indefinitely. After all the vessels have been partly filled with water, they operate simultaneously, so that the water can be raised to any height. Hence a tree constructed on this plan would not be limited in height by any limit to the ascent of sap, but only by considerations of nutrition and resistance to the destroying force of the elements.

Variations in atmospheric pressure act in the same way. With a falling barometer the air in *a* expands and forces water into the vessel *b* above, and with a rising barometer the air in *a* contracts and "draws" water from the vessel *b* below, the valves opening and closing, as required, under the influence of the pressures in the various vessels.

This theory also explains the respiration of plants, which has hitherto been as puzzling as the ascent of sap. In animals, respiration is effected by the muscular contraction and expansion of the chest, and some equally powerful force is required for the circulation of air through the complex cellular structure of plants, in which simple "ventilation" is altogether inadequate. The apparatus described above works even better with gases than with liquids.

In our artificial plant we will, like Nature, make use of every force at our command. The device described will not work in the roots, where change of temperature and access of air are almost prevented by the soil, but the osmotic pressure, which is known, in this connection, as root pressure, is quite able to raise the sap through the roots and to a considerable height above the ground. Our device is superfluous, also, at the top of the tree, where the partial vacuum produced by diffusion and evaporation suffices for the last stage of elevation of the sap.

The capacity of the apparatus, computed in accordance with the laws of expansion of gases, is too small for the proper nourishment of the plant, if it is operated solely by the daily alternation in temperature. But the flow of sap in plants shows several periods of fluctuation in 24 hours, proving that there are other forces at work. Plants breathe, oxidize part of their food and, consequently, generate heat. If we assume that any vessel *a* in our apparatus contains, instead of water, root sap mixed with air and in process of oxidation, the heat generated in the vessel will force part of its contents into the vessel *b* above. After oxidation is completed the heated and expanded gases in the vessel *a* will cool and contract. Hence fresh sap will be drawn from the vessel *b*, beneath, and oxidation will recommence. The vessels *a* may therefore be regarded as simple heat engines, analogous to gasoline motors. When once started they continue to work independently of external changes in temperature, which serve only to start the machine after the winter rest or to keep it going slowly when fuel is lacking or oxidation is checked by cold.

Possibly the vessels, tubes, and valves of our machine may be represented by the intercellular spaces, tracheides, pore-canals and lenticels of the real plant. It is not to be supposed that sap is raised in one operation to the top of a California redwood tree, 450 feet in height, and the assumption that the sap is elevated gradually is in accordance with the necessity of depositing nourishment and the known occurrence of respiration, as proved by the presence of pore-canals, in all parts of the stem. But the strongest argument for the theory here sketched is the fact that it explains the ascent of sap as a result of the generation of heat by the plant, and consequently makes the plant independent of passing weather changes. Whether true or false it at least deprives the ascent of sap of all mystery by showing how it can be produced by natural causes.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prome-theus.

LODGING CONDITIONS IN PARIS AND OTHER FRENCH CITIES.

DR. J. BERTILLON has been led by his study of lodging conditions in cities to the conclusion that the cheap lodgings erected by the benevolent societies should be reserved for large families. There are three good reasons for this restriction. Large families are in greater distress than small ones, they are unable

Diagram of an artificial plant, in which sap is gradually elevated to any height by fluctuations in temperature.

to obtain suitable lodgings in present conditions, and if the charity is restricted to large families it will cost less per capita, so that more good can be done with the same money.

Dr. Bertillon's careful and minute researches prove that it is quite impossible to give relief to all persons who are now improperly lodged. He makes a distinction between "insufficient" lodgings, which have more than one occupant per room, and "overpopulated" lodgings, with more than two occupants per room, and gives the following table for Paris, according to the census of 1901:

Overpopulated lodgings (more than 2 persons per room)	14.3 per cent
Insufficient lodgings (from 1 to 2 persons per room)	37.4 " "
Sufficient lodgings (1 person per room)	23.4 " "
Large lodgings (from 1 to 2 rooms per person)	19.7 " "
Very large lodgings (more than 2 rooms per person)	5.1 " "

Hence one-seventh of the inhabitants of Paris live three or more in one room, five or more in two rooms, seven or more in three rooms, etc. To give "sufficient" lodgings to the 340,000 persons who are now living in this deplorable state of overcrowding and promiscuity would require the expenditure of 1,000 francs (\$200) per capita, or 340 million francs (\$68,000,000) in all.

If the assistance is to be restricted to those who are most in need of it, the following table becomes of interest:

	No. of persons.	No. persons ill-lodged.	Per cent.
Families of 3 persons.....	527,000	72,000 or 13.6	
Families of 4 or 5 persons..	729,000	126,000 or 17.3	
Families of 6 or 7 persons..	282,000	93,000 or 32.9	
Families of 8 to 15 persons.	126,000	50,000 or 39.8	

This table shows that the proportion of the ill-lodged increases rapidly with the size of the family, and that large families should be the first objects of benevolence.

Dr. Bertillon observes that the lodging problem varies in different sections of the city and that the rent paid by the ill-lodged in the heart of Paris would enable them to secure comfortable lodgings in the environs, which can now be quickly and cheaply reached by the Metropolitan underground railway. But even in the outlying sections there are more than 15,000 tenements, each of which is occupied by six or more persons. The first task, therefore, is to relieve these 108,000 persons, and this can be done for about 100 million francs (\$20,000,000).

In many other cities the conditions are similar to those of Paris, as is shown by the following table:

Percentage of Ill-Lodged Families (More than Two Persons Per Room.)

Number in Family.	St. Etienne.	Dunkerque.	Cherbourg.	Reims.	Lyon.
3	24.5	19.4	25.1	8.6	23.6
4	20.3	15.2	17.4	5.8	11.3
5	69.7	53.1	49.9	42.0	21.8
6	69.1	53.3	48.8	41.3	5.7
7	73.9	67.2	57.8	59.8	35.6

From all this it appears evident that the cheap tenements erected by philanthropic societies should be reserved, at least for the present, for families with three or more children. This rule has been adopted by the Society l'Abri, which owns two large model tenement houses in Paris.—Revue d'Hygiène.

THE USE OF AFRICAN ELEPHANTS FOR TRANSPORT SERVICE.

EXPERIMENTS have recently been made in the basin of the Congo, to train elephants for transport service, for the question of transport appears to be one of the most difficult with which the Congo administration has to deal. The African elephant, heretofore of value only for his ivory, may in future contribute in no small measure to a solution of the problem in regions difficult of access by other means. The experiments which have been carried out, up to the present, show that elephants can be used to advantage for portage work in regions where the opening up of the country is most difficult, because of lack of transportation facilities. Contrary to the general belief that Central African elephants could not be tamed, and made to perform the same service as their Asiatic fellows in India, a bulletin is stated by the American consul at Boma to have been issued by the Congo government, announcing the complete success of certain experiments conducted at an "elephant farm" at Api, in the Uele district, in the northern section of the Congo State. Here a small herd of young elephants has been found in captivity for several years, and finally after much effort in training them satisfactory results have been obtained. The director of the elephant station, in an official report, says that these experiments demonstrate that the African elephants can live in captivity, and that by good treatment they can be induced to perform labor. Already the oldest members of the elephant farm at Api execute the portage and traction work of the station. They carry drivers on their backs, and pack saddles with loads. None of the animals is more than seven years old, and since the Indian elephants are most efficient at the adult age, 15 years, it is believed that even better results may be looked for. Mortality among the elephants newly captured has been great, and as yet it has not been possible to attempt to breed them in captivity, but experience is solving the problems of taming; the deaths are now few, and fresh recruits are constantly being added. With a beginning thus made the scope of the work at Api will doubtless be enlarged, and eventually it is expected elephant caravans will be established. Success in the undertaking means a great deal for the future of the country. Despite railways and steamship lines, the Congo will always be a country of forests and of savannas intersected with swamps. European stock does not survive in the tropical heat, and native carriers can be employed only to a certain extent. The elephant is