it to be spherical as a first approximation), A is the distance from the galaxy to the nebula, M is mass of our galaxy, and G is the gravitational constant. However, according to the principle of relativity, no mass can acquire a velocity greater than c, the velocity of light *in vacuo*. Consequently, in order to preserve the law of gravitation, together with the conservation of energy involved, and to agree with the principle of relativity the following equation must be satisfied :

$$h\nu - \mu k\left(1 - \frac{R}{A}\right) = \mu c^2; \quad . \quad . \quad . \quad (4)$$

or, substituting μ by its value from (1), we have

$$h\nu\left[1 - \frac{k}{c^2}\left(1 - \frac{R}{A}\right)\right] = \mu c^2. \quad . \quad . \quad (5)$$

On the right-hand side of this equation c is constant and, therefore, μ cannot vary, which makes μc^2 constant. On the left-hand side of the equation, h is Planck's constant. Therefore, in order to satisfy equation (2), ν which we observe in the photon coming from the nebula, and which is on the left-hand side of equation (2), must have a value different from ν which the photon possessed at the moment of emission, and become a variable frequency ν^1, a function of the argument A.

Equating (2) with (5), we have

$$h\nu^1 = h\nu\left[1 - \frac{k}{c^2}\left(1 - \frac{R}{A}\right)\right]. \quad . \quad . \quad (6)$$

This equation shows that under an acceleration by the field of gravitation a photon keeps its velocity constant by adjusting its frequency so as to compensate for the variation due to the acceleration.

The red shift of the 'expanding universe' is an immediate corollary of equation (6), as the observed wave-length λ^1 is $1/\nu^1$, and, therefore, increases with the distance A.

It seems that the idea presented is worth discussion ; I should be much interested in any comments on the subject.

ANATOL JAMES SHNEIDEROV.
Extension Division,
George Washington University,
Washington, 6, D.C.
Nov. 14.

[1] Abbott, C. G., "The Newtonian Lucretius", *Smithsonian Misc Collections*, 142 (1899). Shneiderov, A. J., "The Exponentia Law of Gravitation and Its Effects on Seismological and Tectonic Phenomena", *Trans. Amer. Geoph. Union*, 61 (1943).

Surface Tension of Solutions

IN a recent paper[1], Wales discusses the approximate relations for the surface tension of regular solutions. He concludes that the surface tension is linearly or quadratically related for ideal and regular solutions respectively to the molar volume fractions of the components.

Two facts, however, limit the applic bility of these relations. (1) The omission to take into account the adsorption at the surface which is responsible for the disagreement between the relations obtained and the Gibbs equation for the surface tension. (2) The neglect of the orientation of molecules at the surface.

In a theory I have recently developed[2] both those effects are accounted for in terms of the monolayer, while the derived relations for the surface tension agree perfectly with the Gibbs equation and cover the whole range of concentrations. At close values of the surface tension, relations analogous to those derived by Wells are obtained, while the surface tension for ideal solutions is linearly related to the surface molar fraction, which indicates the area occupied by molecules of the given species in the monolayer. An inspection of the benzene – carbon disulphide system, discussed by Wells, shows the carbon disulphide molecule to be oriented perpendicular to the surface.

A paper devoted to the statistical treatment of regular solutions and, in particular, to the analysis of the benzene – carbon disulphide system was ready in February 1944 and is to appear shortly in *Acta Physicochimica USSR*.

A. A. SCHUCHOWITZKY.

[1] *J. Chem. Phys.*, **12**, 134 (1944).
[2] *Acta Physicochim. USSR*, **19**, 176 (1944).

Plant-Growth Substances and *Penicillium notatum*

IT was considered of interest to study the effect of plant-growth substances on the production of penicillin by the mould *P. notatum*. Several experiments have been carried out using indole-3-acetic acid and α-naphthalene acetic acid. The study has included the use of various media with the Squibb strain of *P. notatum* (American Type Culture Collection). Heavy spore inocula were added to two quart bottles (flat type) containing about 300 ml. of the medium. The bottles after inoculation were kept at 23–24° C. and 80 per cent humidity. As might be expected, marked stimulatory effects of the growth-substances were found only in the cases of the simple media, such as Czapek-Dox with added brown sugar. The experiments reported refer to penicillin production in the latter medium with 4 per cent brown sugar. Addition of either of these growth-substances at the concentration of 1 part in 30,000 had no effect in a mineral and corn-steep (6 per cent) medium. The titres obtained with the simple medium plus the growth substances are higher than have previously been reported for this medium alone. The practical value of the findings is limited, however, for much higher titres are the rule with the corn-steep media. This work suggests that a part of the good results got with the corn-steep may be ascribed to its containing plant-growth stimulants; but this point has not been checked.

The results of repeated tests have been somewhat erratic because of the variation in bottles inoculated under identical conditions. Almost without exception, however, the bottles containing the growth substances have developed mature mould mats in somewhat shorter times, and the titres of penicillin (both at the same time and at comparable stages during the development of the mat) have been higher than in controls. It is not known whether this is due to a faster growth or to a greater total growth of the mould, or to an increased secretion of penicillin. It is thought that faster growth of the mat will account for the findings, for, of course, the quicker the peak concentration of penicillin is reached, the higher it will be, there being less time for the decomposition of the accumulating penicillin.

A single, complete experiment is given in the table, the titres representing the best bottle of a triplicate group. Repeated experiments gave the same indications, but not usually the same figures.

EFFECT OF PLANT-GROWTH SUBSTANCES ON PENICILLIN TITRES FROM *P. notatum* ON A SIMPLE MEDIUM.

Medium	Days after inoculation	Penicillin (Florey units per ml.)
Control	6	30
Indole acetic acid, 1 in 10,000	6	50
Naphthalene acetic acid, 1 in 10,000	6	25
Control	7	35
Indole acetic acid, 1 in 10,000	7	50
,, ,, ,, 1 in 100,000	7	35
Naphthalene acetic acid, 1 in 10,000	7	40
,, ,, ,, 1 in 100,000	7	50
Control	11	28
Indole acetic acid, 1 in 10,000	11	50
,, ,, ,, 1 in 100,000	11	30
Naphthalene acetic acid, 1 in 10,000	11	30
,, ,, ,, 1 in 100,000	11	45

It is thus seen that indole acetic acid at a concentration of 1 part in 10,000 gives the quickest high titre of penicillin, whereas it is not so active at 1 to 100,000. Naphthalene acetic acid is more active at 1 part in 100,000, giving a titre peak in seven days. The two concentrations mentioned were the only ones studied, and it is likely that the optimal one has not been chosen. Work along these lines is being continued.

S. W. LEE.
E. J. FOLEY.
JEANNE A. EPSTEIN.

Wallace Laboratories, Inc.,
New Brunswick,
New Jersey.

Ripening of the Onion Bulb and Infection by *Botrytis* Species

THE first sign of normal ripening in the onion plant, it is supposed, consists of a local collapse at the neck, resulting in the leaf blades falling over on to the ground while several of them are still green and turgid; this can occur with plentiful soil moisture[1,2], though hastened by drought, and has been attributed (*loc. cit.*) to a softening of the tissues of the neck. The true explanation would appear, however, to be purely mechanical, and connected with the mode of development of the onion bulb. In the absence of bulbing, as in an onion plant growing in short days, new leaves emerge at regular intervals. Each leaf consists of a thin-walled hollow cylindrical leaf base surmounted by a more or less cylindrical 'blade' which is at first solid but later develops a lysigenous cavity. At the junction of the leaf base with the leaf blade a pore is found, through which the next younger leaf emerges. The neck of the actively growing onion plant thus consists of a number of very thin concentric leaf bases enclosing a practically solid core of growing leaf blades. The outermost leaf bases are dead and papery, but even the living ones have little inherent rigidity; the solid core is formed by the blade or blades of the one or two leaves next emerging. When, under the stimulus of long days, bulb development occurs, leaf emergence ceases immediately or soon according to conditions[2,3] and the three leaf initials next due for emergence become instead swollen bulb scales with practically no leaf blade[3]. The result is that after the blade of the last leaf has emerged there are no more to provide the solid core of the neck, which thus becomes a thin-walled hollow tube. This soon buckles and collapses under the weight of the green leaf blades, especially in wind or drought. Experiment has shown that removal of the central core very greatly reduces the resistance of the neck to buckling.

The common horticultural practice of bending onion plants over at the neck to hasten ripening thus appears groundless. If bulbing has not proceeded far enough to stop leaf emergence, the practice can only result in breaking or bruising the next emerging leaf blade, while if leaf emergence has ceased the neck will of itself collapse very soon, though there seems no obvious reason why this should either hasten the drying of the leaf blades or the onset of dormancy, which together accompany ripening.

Before bulbing occurs, the pore at the junction of leaf base and blade is from the earliest developmental stages of the leaf initial blocked by the tip of the subsequent leaf[3]. The last leaf to emerge after bulb development, however, has an open pore, since the next leaf initial forms a swollen bulb scale the blade of which fails to elongate. If, therefore, this last leaf emerges fully before collapse of the neck occurs, the onion plant has then a more or less open pore communicating directly by the hollow neck with the interior of the bulb. Since we have in a number of cases found the swollen bulb scales infected (apparently with *Botrytis* spp.) while the surrounding swollen leaf bases[3] have appeared healthy, it would seem that this probably provides one of the modes of infection of the onion bulb by spores of *Botrytis* spp., which constitutes one of the main problems of economic importance connected with onion culture and storage in Great Britain. Another likely path of infection is via the pores of the other (older) leaves, since these sag open as the leaves wither and thus provide pockets for the lodgment of air-borne spores and probably fairly high humidities for their germination. This would presumably lead in the first instance to infection of the swollen leaf bases rather than of the swollen bulb scales, and this is the most frequently observed condition in the early stages of *Botrytis* 'neck rot'. That infection does in fact occur via these pores is indicated by our observations of the occurrence of 'neck rot' in the greenhouse, where the plants are somewhat etiolated and the necks very much longer than under field conditions. Here the tissues of the leaf bases are killed high up on the neck near the pores, and even the whole neck rotted through at that level, before the bulb shows any obvious infection.

The above considerations provide yet another example of the importance of the cessation of leaf emergence with bulb development in accounting for the behaviour of the onion plant[2].

M. HOLDSWORTH.
O. V. S. HEATH.

Research Institute of Plant Physiology,
Imperial College of Science
and Technology,
London, S.W.7.
Jan. 26.

[1] Heath, O. V. S., *Ann. Appl. Biol.*, **30**, 208 (1943).
[2] Heath, O. V. S., *Ann. Appl. Biol.*, **30**, 308 (1943).
[3] Heath, O. V. S., and Mathur, P. B., *Ann. Appl. Biol.*, **31**, 173 (1944).