grasses and fodder crops but, so far, no systematic work has been undertaken on the utilization of sewage for raising grain or remunerative crops. An activated sludge plant has recently been installed at the Agricultural Research Institute, Coimbatore, and experiments utilizing the sludge as manure and effluent for irrigating remunerative crops have been undertaken.

Interesting experiments on the relative values of effluents and sludges from sewage treated in different ways are in progress in the farm attached to the City of Nagpur. Mention should also be made of the work carried out at Nasik, Indore and different other cities, but the present space is hardly adequate to do justice to them all.

Although much useful headway has already been made, a great deal yet remains to be done. The system of irrigation has still to be improved so as to secure maximum benefit from all the plant nutrients present in sewage. The dangers of crop lodging have to be avoided without sacrificing the fertilizing value of nitrogen. The conditions relating to the application of sewage to grain and remunerative crops have yet to be standardized: crop requirements of ingredients other than those present in sewage have to be determined and judiciously applied. The quality of crops raised on sewage has to be systematically investigated with particular reference to taste, keeping and nutritive value. The transformations attending the various pathogenic and putrefactive organisms normally present in sewage have to be carefully determined and the relation of those organisms or the products of their metabolism to plant development, animal health and human welfare elucidated. In view of their importance in relation to both agriculture and public health, it is to be hoped that the above and related problems will soon receive the necessary attention at the hands of the workers concerned and that sewage farming will, before long, be placed on a sound economic and hygienic basis.

A Note on the Expanding Universe.

By Prof. A. C. Banerji, M.A., M.Sc., F.R.A.S., *Allahabad University.*

EDDINGTON has shown that Einstein world is unstable and that any small disturbance would start it expanding or contracting. He has also shown that conversion of matter into radiation tends to retard expansion (*M.N.R.A.S.*, May 1930), whereas McVittie has found in his revised investigation that the effect of gradual condensation of matter into galaxies would tend to cause expansion (*M.N.R.A.S.*, Jan. 1931). The shift, towards the red, of the spectral lines of the light emitted by very remote objects like spiral nebulæ is responsible for the assumption that these bodies are receding from us, and, consequently the Universe is expanding. Hubble and Humason formulated from available data the following velocity-distance relation of the receding object within an error of 10%,

$$\underset{\text{(in km. per sec.)}}{\text{Velocity}} = \frac{\text{Distance (par-secs.)}}{1790}$$

(*Astrophysical Journal*, Vol. LXXIV, 1931.)

This corresponds to a velocity of 558 km. per sec., per million par-secs. This is equivalent to a velocity of about $\frac{1}{1800}$ of the velocity of light for a distance of a million light-years. Calculating on this basis we see that a nebula which has receded to a distance of 1,800 million light-years ought to have the limiting velocity equal to that of light, and the limiting volume will then be nearly three times that of the Einstein's static Universe, which is supposed to have a radius of about 1,200 million light-years. When the Universe has expanded to this limit, several difficulties arise and it becomes a legitimate question to ask as to what would now happen to the Universe. Dynamically, matter cannot have any velocity greater than the velocity of light. But it has, on the other hand, been suggested that matter possessing velocity greater than that of light belongs to a different disconnected world which cannot bear any physical relation to us. This is only a suggestion and its validity or otherwise can be determined only by subsequent work. It is also possible to make another suggestion. If, due to any causes (of which we have so far no evidence), as soon as the particles of the nebula attain the velocity of light they are transformed into radiation, then such a process, as shown by Eddington, would check expansion, and the Universe may subsequently begin to contract. Now, moreover, mass (relative-mass) of a receding nebula becomes infinite when in the limit it attains the velocity of light, and consequently the total mass of the Universe becomes infinite. When nearing this limit the mass of the Universe increases very rapidly, and the structure of the Universe would then be like an expanding hollow shell with increasingly dense matter on the surface and comparatively little mass inside. One may ask if the conservation of mass (relative-mass) is an invariable law of Nature (Eddington, *The Mathematical Theory of Relativity*, p. 33), then how has this increase in mass been brought about? Or, shall we have to say that the mass also is not conserved? One is confronted with a similar difficulty in the theory of Special Relativity. Suppose we have two particles of rest masses M and M′ (with respect to each other) moving relative to each other, then we can calculate the total mass of the system in two different ways. If M be assumed to be at rest and M′ moving with a velocity V, then the mass of the latter changes and becomes $\frac{M}{\sqrt{1-\frac{V^2}{c^2}}}$ where c is the velocity of light, and the total mass of the system becomes $M+\frac{M'}{\sqrt{1-\frac{V^2}{c^2}}}$ with respect to the first. On the other hand, if we suppose M′ to be at rest and M to be moving with velocity —V, then the total mass of the system comes out to be $M'+\frac{M}{\sqrt{1-\frac{V^2}{c^2}}}$ with respect to the second. These two expressions for the total mass are different. In the first case the total energy of the system (apart from interaction energy which, if any, will be the same in both the cases) is

$$Mc^2+\frac{M'c^2}{\sqrt{1-\frac{V^2}{c^2}}} = Mc^2 + M'c^2 + \tfrac{1}{2}M'V^2$$

neglecting terms of higher orders. In the second case the total energy (apart from interaction energy) neglecting terms of higher orders, comes out to be

$$M'c^2 + Mc^2 + \tfrac{1}{2}MV^2.$$

These two are different and the law of conservation seems to fail. It is well known that the Principle of Relativity has been developed from the motion of one body, and no way has yet been found for treating the motion of two bodies moving relatively to each other and possessing inter-action energy. The necessity for development along these lines is very great because, without some guiding light about this problem, it is not possible to make any progress in the study of the Universe as a whole, as has been pointed out in this note, and also in the Study of Nuclear Physics.

The formula for the rate of the expansion can be put as $\frac{da}{dt}=\sqrt{\tfrac{1}{3}a^2\lambda-1+\frac{4M}{3\pi a}}$, where M is the mass, a is the radius of the Universe at any time and λ is the cosmical constant in Einstein's gravitational equation. (*M.N.R.A.S.*, May 1930.)

When $M\rightarrow\infty$, $\frac{da}{dt}\rightarrow\infty$.

As matter cannot have any velocity greater than the velocity of light, the above equation breaks down as soon as the receding nebula attains the velocity of light. It has been calculated that the radius of the Universe (Einstein Universe) was originally about 1,200 million light-years. So, when it began to expand, the nebulæ near about its boundary must have started with a velocity equal to $\frac{2}{3}$ of the velocity of light. Hence, at the present moment these nebulæ must have a velocity greater than this. This extraordinarily high velocity as well as other difficulties mentioned above throw a reasonable doubt on the theory of expanding Universe, and the cause of the shift of the spectral lines may be looked for elsewhere.

Milne has tried to explain the receding motion of the nebulæ by abandoning the notion of curvature and expansion of space and by regarding the observed motions of the distant nebulæ as their actual motions in Euclidean space (*Nature*, July 2, 1932). In his distribution-law for the velocities of particles, he permitted a continuous distribution of velocities up to c, the velocity of light, which does not appear so probable for a particle. The velocity of a nuclear electron is also supposed to have a velocity practically equal to that of light. The same difficulty crops up again, *i.e.*, the mass of the electron as well as of the particle becomes infinite.

Macmillan supposes that there is a leakage of energy from the light quantum or photon in its long journey of millions of years from the distant nebulæ due possibly to collisions with other photons, or perhaps to an inherent instability in the photon, so that frequency diminishes with energy and the spectral lines are shifted towards the red (*Nature*, January 16, 1932). His suggestion deserves more notice than it has so far received. He supposes that the rate of the loss of energy per unit distance from the photon to its total energy is constant, *i.e.*, $\frac{1}{\epsilon}\frac{d\epsilon}{dx} = -a$, where $\epsilon = h\nu$, h being the Planck's constant, ν the frequency and a a constant. We get ultimately $\nu = \nu_0 e^{-ax}$. His first suggestion that the loss of energy may be due to collisions with other photons is not borne out by any physical evidence; for example, recent experiments on the collision of photons have yielded negative results, and, moreover, according to Bose statistics it is inherently impossible for two photons to collide.

It is possible that photon may lose energy by passing through intervening gravitational matter, but unless the density of this matter is uniform throughout the whole track of the photon, the above rate for its loss of energy will not remain constant. If mass or energy is not conserved, it is then possible that photon may lose its energy due to some sort of inherent instability, but no physical evidence is yet forthcoming to show if it is actually the case. It seems probable that if this suggestion be worked out, a true explanation of the shift of the spectral lines may be found.

Letters to the Editor.

Yellowing of Sugarcane in the District of Saran in North Bihar.

IN the Government Farm at Sepaya, a kind of unhealthiness has been noticed, since 1925, occurring in sugarcane, particularly in the variety Co 213, between the months of July and September during breaks in the monsoon after some heavy showers of rain. This is the time that canes make a rapid growth, but apparently sound plants suddenly show, on the tips of the fourth (or the fifth) leaf, a yellowing which travels rapidly down and affects the whole leaf. The top leaves become pale quickly and the plant ceases to grow. The old roots are found to have decayed and new roots are not formed. The cane remains long in this condition and then withers.

The first signs of distress are seen in canes growing on light soils and in soils having a high concentration of soluble salts the (OH)′ ion concentration being such as to raise the pH value to 9.0 or higher. The yellowed leaves show a large accumulation of carbohydrates in them, but their nitrogen content is low. Thus a physiological unbalanced C : N ratio sets up. In healthy plants this ratio of carbohydrate to nitrogen does not exceed a third of what is found in unhealthy cases.

Stirring up of the soil followed by irrigation checks the disease, but good and quick results follow the application of nitrogenous or nitrogenous and phosphatic fertilizers and a fresh earthing up. The plants throw up new roots, yellowed leaves turn green and growth starts again. The cause of the sickness appears to be a deficiency of available nitrogen in the soil due to retarded nitrification just when the growing plants are making a heavy demand on it. Any treatment which quickens the rate of nitrate formation and holds them up to the plants makes the canes recover and grow healthy again.

M. N. GHOSH.
Agricultural Research Institute,
Sabour,
November 6, 1932.

The Effect of Low Pressure on the Life of Liquid Drops on the Same Liquid Surface.

THE effect of low pressure on the life of liquid drops on the same liquid surface was studied by means of a bottle of 1 litre capacity fitted with a mercury manometer, a three-way stop cork and a vacuum pump. The primary drops as well as the secondary drops of Boys' soap solutions were formed by means of a burette fixed into the mouth of the bottle, at different pressures of the air inside it. The following results have been arrived at, from the observations taken:—

1. That the life of the floating drops on the same liquid surface depends upon the pressure of the air (or the surrounding medium). The lesser the pressure of the air, the shorter is the life of such drops.

2. That the life comparatively decreases rapidly in the beginning, but slowly afterwards with the decrease of pressure.