and tissue ADA binding factor in a high state of purity. Purified ADA awaits trials of its clinical usefulness. Also, on theoretical grounds, deoxycytidine may have therapeutic benefits for NP and ADA deficient.

J. F. Smyth (Royal Marsden Hospital, Sutton, Surrey) has infused terminal cancer patients and patients with T cell acute lymphocytic leukaemia with deoxycytidine, a potent ADA inhibitor. He achieved striking lymphocytocidal effects. Potent immunosuppressive and oncolytic agents may emerge from the study of these rare immunodeficiencies which result from a failure of purine breakdown. □

Multipion production in relativistic heavy-ion collisions

J. M. Irvine

IN recent years the nuclear physics community has been excited by the possibility of new accelerator systems capable of producing relativistic heavy-ion beams. There has been theoretical speculation for several years about using such beams for producing new, exotic nuclear phenomena such as superheavy elements, nuclear shock waves, pion condensates (the nuclear analogue of a ferromagnetic phase transition) and quark matter.

If one fires high energy nucleons at one another the most obvious products are pions, and one of the first things to be understood about relativistic heavy-ion collisions then is the pion production. Earlier this year (Fung *et al. Phys. Rev. Lett.* **40**, 292; 1978) data became available from the Bevalac at Berkeley on negative pion production in relativistic heavy-ion collisions from beams of ^{40}Ar at 0.4, 0.9 and 1.8 GeV/nucleon and ^{12}C beams at 0.4 and 2.1 GeV/nucleon on targets of LiH , NaF , Ba_2 and Pb_3O_4 . As was to be expected theoretical papers aiming to interpret the data have followed thick and fast. The simplest picture (Vary *Phys. Lett.* **40**, 295; 1978) considers that the colliding nuclei are moving so much faster than the internal velocities of the nucleons of which they are composed that this internal motion can be ignored and the heavy ion collision can be viewed simply as a large number of independent nucleon-nucleon collisions. Vary's calculations predict too many events with high negative pion multiplicities, that is, events where more than 15 negative pions are produced, and attempts to correct this feature by allowing the pions to interact with the

nucleons to produce baryon resonances have not been successful. A better account of the pion multiplicities is provided by the fireball model (Gyulassy & Kauffman *Phys. Rev. Lett.* **40**, 298; 1978). In this model, as the target and projectile sweep by each other, the material in the geometrical overlap is swept out and assumed to be at rest in the centre of mass frame. The enormous initial kinetic energy is assumed to be converted into internal thermal energy. The pions are assumed to be produced in this extremely hot fireball fragment (see Fig. 1). Gyulassy and Kauffman conclude that this model is adequate to explain the pion multiplicity data and come to the conclusion that the independent nucleon-nucleon model predicts too many high multiplicity events because it ignores pion absorption. They go on to assert that

there is a very large class of dynamical models which will give results identical to those of the fireball model: the only requirements on the models being that the pions are uncorrelated and that the average pion multiplicity is correctly given.

This assertion seems to be supported by recent results of Afek *et al. (Phys. Rev. Lett.* **41**, 849; 1978) using the collective tube model. This model uses a geometrical picture of the heavy ion collision like the fireball model and considers the collision of two 'tubes' of nucleons in the target and projectile nuclei. In the centre of mass frame the colliding tubes are Lorentz contracted into narrow disks and the model then assumes that the tube-tube collisions resemble elementary particle-particle collisions. The agreement between the predictions of this model and the data of Fung *et al.* is extremely impressive. Afek *et al.* go on to claim that the agreement between the predictions of the colliding tube model and statistical thermodynamic models, like the fireball model, is entirely accidental and will disappear at higher energies for heavy projectile-heavy target systems. □

Sinks and sources of plant nutrients

from Peter D. Moore

COMMUNITIES of emergent aquatic plants are known to be among the most productive found in temperate latitudes. Dykijora (*Photosynthetica* **5**, 329; 1971) examined three such littoral plants, *Phragmites communis*, *Typha angustifolia* and *Scirpus lacustris* and obtained values for their productivity (means for the whole growing season) of up to 25, 39 and 21 $\text{g m}^{-2} \text{ day}^{-1}$ respectively. In part these high values can be explained in terms of the structure and arrangement of leaves; leaf area index is high for all these species and all possess underground rhizomes which act as storage organs and which permit rapid leaf production at the commencement of the growing season. A further factor which contributes to the high productivity of swamp habitats is the normally adequate water supply and the frequently rich provision of nutrients in the water flow.

Tropical swamps also have very high productivity. For example, Thompson (in *The Nile, Biology of an Ancient River* (ed. Rzoska) Dr W. Junk, The Hague; 1976) has estimated that papyrus (*Cyperus papyrus*) swamps in

East Africa achieve values of 35 $\text{g m}^{-2} \text{ day}^{-1}$. As with their temperate counterparts, these plant communities also place high nutrient demands upon their environment and accumulate these nutrients within their living biomass and in the peat which develops from the undecomposed litter.

Gaudet (*Ecology* **58**, 415; 1977) has measured the nutrient uptake capacity of papyrus and has obtained the following values ($\text{g m}^{-2} \text{ yr}^{-1}$) N, 103; P, 8; K, 130. These figures are similar to published data concerning *Typha latifolia* for P and K, but are twice as high for N. Such very high accumulation rates have subsequently led Gaudet to consider the value of such papyrus communities for the extraction of nutrients and hence the reduction of eutrophication in East African lakes. Nutrient cycles being what they are, however, much of the NPK build up in the biomass is released in litter decomposition. Gaudet has measured the rate of nutrient release, both through decomposition and through the direct leaching of living tissues and has estimated the proportion of the annual nutrient uptake which would enter swamp peat. The figures he obtained are N, 63%; P, 1% and K, 1%. Thus most of the P and K are released back into the environment,

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