some of these fantasy experiments can actually be performed, and the measuring rods and clocks, albeit in technically unrecognisable form, have become a reality. Vessot and Levine point out other experiments which are feasible with current technology using clocks in space. One of these is the measurement of the Lense–Thirring frame-dragging effect, which is a sort of vortex in space in the vicinity of a rotating massive body. Determination of the magnitude of the effect due to the Sun by orbiting clocks near the solar surface in a drag-free satellite, would enable an accurate measurement to be made of the total angular momentum of the Sun, a quantity which is crucial to our understanding of stellar structure. Another possibility is the detection of very low frequency gravity waves which, when washing through the Solar System, cause long-period fluctuations in clock rates. There is no doubt that as technology improves, more and more of the exceedingly minute, though highly significant distortions of space and time predicted by Einstein's theory will come within the scope of direct experimental verification. □

Micro-ecology

from N. MacDonald

A RECENT review in *Nature* (Bloom **279**, 21; 1979) of immunological aspects of parasitism, discusses the methods adopted by parasites to survive within host cells. A full issue of the *Proceedings of the Royal Society* (**B204**, 1979—arising from a meeting held last year) has recently been devoted to wider aspects of the cell as a habitat for other cells, covering mutualistic interactions as well as parasitism. The evolutionary implications of early symbionts (cells inhabiting cells) which may have become integrated into the structure of more complex cells (present-day mitochondria and chloroplasts for example), have been widely discussed, and are reviewed by F. J. R. Taylor and by J. M. Whatley *et al.* (These and all subsequent references are to papers in the previous reference). The general topic of the micro-ecology of contemporary symbionts, their mechanisms of adaptation to the intracellular environment, and the regulation of their populations by that environment, is probably less widely known.

Various kinds of association of host cell and symbiont can be arranged in order of increasingly close integration. Most symbionts are segregated by enclosure in a membrane-lined vacuole. Those that are not can typically not be grown outside the host cell. These are presumably candidates for a process in which they lose their separate identity and merge with the host cell, at any rate in cases where the association is mutually advantageous.

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This potential loss of identity is not the only way in which the cell as an environment is vastly different from the physical environments of large-scale ecology. Regulation of the population of the symbiont is necessary lest it grows to the extent of bursting the host cell, as well as for restraining the competition of the symbiont for resources needed by the host. In all cases of stable association in which the symbiont is capable of separate existence, the maximum intracellular growth rate of the symbiont population is less than the maximum extracellular growth rate (D. C. Smith). Some of the regulatory mechanisms (as discussed for example by L. Muscatine and R. R. Pool for intracellular algae) are reminiscent of those encountered in animal ecology, at least in so far as one regards the environment of a particular species as including its predators and competitors. The host cell may expel the symbiont, consume it or starve it by competing for a resource. One radically different mechanism, for which there is is now some evidence, is the triggering of mitosis in the symbiont by mitosis of the host.

J. W. Moulder discusses the cell as an extreme environment, explicitly examining the partial analogy with physical extreme environments, such as hot springs or salt lakes. Such environments are characterised by low diversity of the species that inhabit them; frequently there is a single dominant species. This species is likely not only to have adapted to the presence of the primary non-biological limiting factor, such as temperature or salinity, but to have become dependent on it. The limiting factors of a host cell are of a more varied and active nature. The cell can exclude or destroy most potential symbionts, so that a single dominant symbiont, which has managed to evade these defences, is typically present. Some kinds of intracellular parasite possess special techniques to gain access to cell interiors, while others simply allow themselves to be engulfed by macrophages, while contriving to avoid subsequent destruction. Enclosure of the symbiont by a vacuole can be thought of as tempering the severity of the extreme intracellular environment.

To give a final twist to the discussion of this complex and intriguing kind of biological association, M. H. Richmond discusses the bacterial cell as a habitat for extra-chromosomal DNA fragments, such as plasmids, which can specify resistance to antibiotics or the ability to metabolise novel substrates. In this context plasmids can be regarded as molecular symbionts whose effect is to allow the bacteria which carry them to penetrate otherwise inhospitable habitats. □

A hundred years ago

THE first public act passed by the U.S. Congress during the present session, was one making an appropriation of 200,000 dollars for the construction, under the direction of the Secretary of the Treasury, for the National Board of Health of a vessel provided with suitable refrigerating apparatus, for the purpose of determining the possibility of destroying the yellow fever infection by intense cold. The act first introduced had special reference to the apparatus of Prof. Gamgee, but as passed it is within the power of the Secretary to select any device that will, in the opinion of the National Board of Health, best answer its purpose.

THE *Colonies and India* furnishes some interesting particulars respecting the so-called "vegetable ivory," which is now so much used as a substitute for ivory. The vegetable ivory nut is the produce of a species of palm found wild in South America and Africa. Inside the hard shell is the white kernel, which being softer than ivory and easily carved, as well as readily dyed, and being less brittle than bone, is largely used in making buttons, &c. The unripe fruit consists of a green shell, containing a watery fluid, which, as the nut ripens, gradually thickens until it becomes a pulpy mass, and eventually hardens into solid matter. The water, though bitter to the taste, is wholesome, and often renders invaluable service to travellers, who cannot otherwise obtain water to drink. The tree (*Phytelephas macrocarpa*) on which the fruit grows is unlike an ordinary palm, having little or no stem and drooping downwards, especially when the weak branches are overweighted by the six or seven bunches of nuts, each containing six or seven seeds, inclosed in thick heavy shells and outer sheath, and weighing altogether from 20 to 24 lbs.

EXTRAORDINARY finds of gold have lately occurred in the gold-fields of Dutch and French Guiana and are causing great excitement.

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