presented evidence that one accompaniment of LTP is an increase in the number of receptors for glutamate, which is the putative neurotransmitter at these synapses.

Last year Lynch and Baudry [2] unveiled a theory, in which fodrin (a neuronal analogue of spectrin, the principal protein of the red cell cytoskeleton) plays an essential part in these changes. They suggest that, in the neurones stimulated in LTP, there is an increase in postsynaptic calcium concentration; this then activates the calcium-dependent protease, calpain 1, which uniquely attacks fodrin. The degradation of fodrin leads to exposure of cryptic postsynaptic glutamate receptors, so increasing the postsynaptic potentials evoked by subsequent exposure to glutamate.

In support of the theory, Siman, Baudry and Lynch [3] have demonstrated a relationship between the calcium-stimulated enhancement of glutamate binding and the degradation of fodrin, both effects being blocked by leupeptin, an inhibitor of calpain 1. More remarkably, perfusion of rats' brains with leupeptin, which on Lynch's scheme should inhibit their capacity to learn, indeed impairs the performance of various behavioural tasks. On page 225 of this issue, the same authors provide evidence that causally links the degradation of fodrin to the calcium-stimulated increase in glutamate binding [4].

Siman *et al.* have used antibodies (or their univalent fragments) to fodrin to protect the fodrin on hippocampal synaptic plasma membranes against calpain 1. The membranes thus treated no longer increase their glutamate binding in response to calcium; a good correlation is observed between the amount of antibody bound and the response. This demonstrates that the effect of leupeptin is not a consequence of blocking calpain activity *per se*. It is also shown that the antibody effect does not arise from any sequestration of calcium or from a non-specific perturbation of the membrane by immunoglobulin. In the absence of antibodies only some 20 per cent of the fodrin is degraded, suggesting that a sub-population, possibly localized, is involved in the effect. (It is perhaps worth recalling that when similarly activated by calcium in the red cell, calpain 1 does not preferentially attack spectrin, but rather its associated proteins, 4.1 and ankyrin [5], which coexist with fodrin in the neurone).

The sequence of events posited by Siman *et al.* certainly embodies important features required for a physiological mechanism of memory. The initial event could be effected by the brief physiological changes that accompany synaptic transmission. The scheme also accommodates the requirement for a long-lasting change, for if the membrane cytoskeleton regulates the shape of the neurone, as it does that of the red cell, then a structural perturbation could readily be envisaged to result in the altered ultrastructure of the dendritic spines that seems to occur in the hippocampus of rats subjected to LTP [6].

The elucidation of the molecular basis of memory has been frustrated by the extremely circumscribed nature of the elicited response, which is beyond existing techniques to discriminate. Although significant progress has been made in understanding changes in synaptic efficacy in the nervous system of *Aplysia* and other invertebrates [7], our knowledge of the repertoire of possible presynaptic and postsynaptic changes is still fragmentary. If, indeed, something as simple as the cleavage of a single protein represents a major and universal event in the process of learning, this would be cause for new hope, if not yet for dancing in the quad. □

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Atmospheric physics

Atomic oxygen from a balloon

from Gaston Kockarts

REMOTE sensing techniques provide an efficient way to investigate the gas composition and structure of the terrestrial atmosphere. It is, however, necessary to avoid the problems of absorption by other atmospheric constituents and to have an instrument with a sufficiently high resolution to discriminate the spectral signature of a specific component from others. Although the infrared emission at 63 μm of atomic oxygen has been detected a few times during rocket flights above 85 km altitude in the thermosphere, T.A. Clark and colleagues have achieved the first measurements at stratospheric height, by using especially developed detectors carried in a balloon. Their measurements, reported on page 206 of this issue, are important because this emission is thought to play a significant role in the cooling of the upper atmosphere.

A physical nomenclature of the Earth's atmosphere can be based on the vertical distribution of temperature. Starting at ground level, the troposphere is characterized by a decrease of temperature, which increases again in the stratosphere, above 10 km, owing to the absorption of solar ultraviolet light by ozone. Above 50 km, in the mesosphere, the temperature decreases again as a consequence of infrared cooling by carbon dioxide. It reaches a minimum of 150 - 200 K at approximately 85 km, where the thermosphere starts. In this region, atmospheric molecular oxygen is progressively photodissociated by solar ultraviolet radiation of a wavelength shorter than 175 nm; in this way, atomic oxygen becomes a major atmospheric constituent. The absorption of solar ultraviolet radiation induces a heating of the thermosphere, the temperature of which increases with height until it reaches an altitude-independent value above 500 km of 600–1,800 K depending on the level of solar activity. Heat is transported downwards by thermal conduction, but can also be removed from the atmosphere by infrared emission from atmospheric constituents which have been excited through collisions or through reactions with other components.

The spectroscopic ground state of atomic oxygen is a triplet level and the excitation energy for the 63 μm line is only 0.02 eV, which is of the same order of magnitude as the thermal energy of the thermospheric constituents. Therefore, by collisions with the ambient gas, atomic oxygen in its ground state can be excited and the 63 μm line emitted. For a long time, this mechanism was considered the principal cooling effect in the thermosphere. However, in *Geophysics Research Letters* **7**, 137; 1980, I showed that the 5.3 μm infrared emmission from nitric oxide, a minor thermospheric constituent, is more efficient; paradoxically, the fundamental reason for less efficient cooling by atomic oxygen is its great abundance, which is responsible for a reabsorption of the 63 μm emission. The complexity of the radiative transfer problem will be further increased if the usual assumption of local thermodynamic equilibrium is not valid, which can only be ascertained by accurate measurements of the 63 μm emission.

Clark and colleagues demonstrate the feasibility of observing the infrared emission of atomic oxygen from stratospheric heights. The interferograms obtained with the Fourier spectrometers have sufficient resolution and sensitivity to discriminate the 63 μm emission from atmospheric emissions such as water vapour and its isotopes. Were the technique to be adapted for use on a satellite, it could lead to vertical profiles of the infrared emission of atomic oxygen, and, in principle, such profiles could be used to determine the abundance of atomic oxygen, which is the progenitor of atmospheric ozone. Although fundamental atmospheric infrared observations are usually made at shorter wavelengths, Clark *et al.* have shown that an astronomical detector, such as theirs, can provide valuable atmospheric results in the 50–100 μm wavelength range, showing the value of a multidisciplinary approach. □

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