experimental and theoretical investigations of these strange objects, and a further contribution has been made by A. S. Lapedes and K. C. Jacobs of the University of Virginia in the January 3 issue of *Nature Physical Science* (**235**, 6 ; 1972).

The worlds of the tachyons and tardyons meet at the luminons, which hopefully interact with both, so that the natural way for tardyon beings to search for tachyons is by examining processes in which luminons are produced by the first and detected by the second. Photons are obvious candidates for this role, and one such process might be through what is known as Čerenkov radiation. This radiation may be thought of as an electromagnetic shock wave (rather like the bow wave of a ship) emanating from a charged particle which travels with a speed in excess of the light speed in that particular medium, just as a supersonic aircraft produces a sonic boom when it travels faster than the sound speed in air. Of course, Čerenkov radiation cannot be produced in free space by charged tardyons, because they can only travel at less than the vacuum light speed, but in a material medium the light speed is slower than in the vacuum, and it is in such a medium that Čerenkov radiation is observed. But for charged tachyons, the phenomenon should occur even in free space. The trouble is that a tachyonic electron would radiate all its energy in this way in about 10^{-19} seconds. A neutral tachyon would not be subject to this electromagnetic dissipation, however, but would still undergo an analogous gravitational Čerenkov effect that is a factor of some 10^{33} times less transient for a tachyonic neutron, giving it a "lifetime" of about 2 million years.

A formula for the radiation rate of these Čerenkov gravitons (a graviton is a quantum of the gravitational field) is derived by Lapedes and Jacobs. Their method is quite straightforward, being a direct analogy with the electromagnetic theory. Just as a charge can be the source of electromagnetic waves, so the stress-energy-momentum tensor can be the source of gravitational waves and, for weak fields, the expressions may be taken over more or less intact. The result is, as expected, a formula for the rate of energy dissipation which is similar to the corresponding electromagnetic formula, apart from the all important factor of 10^{33}. Inspection of the formula shows a characteristic "decay" time which is proportional to m^{-3}. The authors also point out that if a tachyon has zero energy (called a transcendent tachyon) then the radiation rate is zero. This is in contradistinction to an earlier conclusion reached by L. S. Schulman.

The two chief questions in this subject have always been how can one detect tachyons and where does one look for them? If the possibility of these gravitational "booms" is accepted, one might expect to detect them using apparatus similar to Weber's famous gravitational wave detector. Unfortunately, it seems that only cosmic sources could provide sufficient energy to make the detection of such booms a possibility using present techniques, but Lapedes and Jacobs do suggest (perhaps not too seriously) that tachyon objects (stars?) may reside at, or be produced in, the galactic centre, and be contributing pulses of gravitational radiation. Failing this, the ever fruitful big-bang origin of the universe is always a good place to produce anything, tachyons included.

FRESHWATER FISH

Revision of North American Chubs

from a Correspondent

THE carp family (Cyprinidae) is one of the most successful groups of living fishes, and is the dominant element in freshwater fish faunas of the northern hemisphere. In northern America the cyprinids attain a degree of diversity which is probably unsurpassed elsewhere, and the profusion of species shows a striking degree of ecological variation without departing too greatly from the basic morphological framework of the group. Not surprisingly, there has been considerable confusion in the past between closely related species, and also failure to recognize polytypic species groups, not least in the genus *Nocomis*, popularly known as chubs in the eastern States. That this confusion has been long standing is illustrated by two recent articles by Ernest A. Lachner and Robert E. Jenkins (*Smithson. Contr. Zool.*, No. 85, 1 ; and No. 91, 1 ; 1971) in which they describe three previously unrecognized species from the eastern United States.

The first article is a review of the systematics, distribution, and evolution of the genus *Nocomis* of which previously three widely distributed and well differentiated species were known. Studies over a number of years, however, showed that these species are in fact species groups rather than clearcut taxa in their own right, and each contains three forms.

One feature which Lachner and Jenkins have used with considerable success has been the careful mapping of the abundance and pattern of head tubercles, a feature common to all cyprinids. These tubercles first appear in juveniles of between 30 and 80 mm body length as small round, light to grey areas in the deeper epidermis; in females they often remain at this stage of development, although in some species females develop a more distinct spot. In males just before the breeding season the tubercles are developed into prominent, pearl tinted pimples, both on the head and the pectoral fins. They are deciduous after spawning, but leave recognizable scar tissue. Lachner and Jenkins find that the distribution, number, size and developmental patterns of the head tubercles represent the most important critical characters in the separation of the species of *Nocomis*. Using these characters, and more traditional criteria, Lachner and Jenkins have revealed a most interesting pattern of distribution within the three species groups.

In their second article Lachner and Jenkins consider the *N. biguttatus* group, where a similar distributional pattern emerges with the nominate species widely distributed through the north central United States, and the two recently recognized species have restricted distributions. *N. asper* has a centre of distribution in the Ozark highland part of the Arkansas River drainage, and *N. effusus* is found in the Green and Cumberland branches of the Ohio River and the Duck system of the Tennessee.

Crested, nuptial male *Nocomis micropogon* (from *Smithson. Contr. Zool.*, No. 85, 47 ; 1971).

The chubs of the genus *Nocomis* are moderately large fish, some species growing to 10 inches long, but they had formerly been little studied because they inhabit moderately deep, swiftly running rivers. Lachner and Jenkins's studies show the value of careful revisionary work to the proper understanding of the systematics of this genus—basic data for the appreciation of the distributional history of the freshwater fish fauna in the eastern states of North America.