

suggests that it will be regarded as the "main discovery of this conference that gluons exist."

His evaluation appears to be recommending itself to many physicists. It is especially welcome to those who seek grand unification theories. These are formulations that would unite all of physics, all forces, in a single formulation. The indication that gluons exist and therefore that the color force may behave in a similar fashion to quantum electrodynamics, which was always the beau ideal of subatomic physics, gives hope that such a unification can take place. There are two (or perhaps one and a half) other forces to make their way into a total unified theory of physics: gravitation and the weak nuclear force, which governs many of the slow radioactive decays. Gravitation (whose quantum would be the graviton) is usually put aside by particle physicists since it has no observable effect in particle physics at present energy levels. The weak force has three field quanta called the intermediate vector bosons, which are now seen as close relatives of the photon even though they have never yet been discovered. (They are the subject of intense searches). Nevertheless, one of the great theoretical and experimental achievements of the last few years has been the unification of electromagnetism and the weak force into a single framework that is now being called electroweak or by some quantum asthenodynamics. The major practical task then for the grand unification theorists is to unite electroweak and quantum chromodynamics. The determination that the two behave in analogous fashion is taken by many to be an indication that efforts at grand unification may be on the right road.

But not everyone is on the bandwagon. The theory of quantum chromodynamics itself prohibits quarks or gluons from ever leaving the confines of the hadrons in which they are bound up. They may be exchanged and interact when the structures they build interact, but they do not fly free as electrons, protons or lambda hyperons can. Therefore, any evidence of them must be indirect. The jets are the best, giving a definite kind of signal, but they are controversial, and some commentators are critical.

Theorist John R. Ellis of the CERN Laboratory in Geneva, who is regarded as a "guru" by some younger physicists, made a remark about not being able to tell quantum chromodynamics from a hole in the ground. A more delicate phrase came from another theorist who told her colleague across the table, "This discovery of gluons was not my interpretation of what happened."

Conviction is likely to spread further and faster, Harari suggested in a remark seconded by Fermilab Director Leon M. Lederman, when higher energies are available. Then the three jets will become narrower and more distinct and therefore

perhaps convince more people.

Another possibility is the discovery of a particle built entirely of gluons. Unlike photons, gluons are capable of exerting forces on each other, a quality that depends on an important characteristic of the theory of quantum chromodynamics. It is conceivable that a "glueball" might appear, a conglomeration of gluons stuck together. No one seems yet to know what would be decisive evidence of a glueball, but supposing there could be, it might convince some physicists that quantum chromodynamics is what it says it is. Chris Quigg, head of the theory group at Fermilab, quotes a colleague telling a third colleague what will convince doubters of the legitimacy of quantum chromodynamics: "When you've got 'em by the glueballs, their hearts and minds will follow." □

## NRC urges reform in undergrad math

Undergraduate mathematics departments must redefine the traditional mathematics major to increase its applicability, its flexibility and its scope. This conclusion emerged from a recently completed three-year study undertaken by a special committee of the National Research Council. To encompass increasing applications, the committee recommends that the number of credits required in the undergraduate mathematics major must be increased.

The NRC's blue ribbon committee of mathematical scientists, chaired by Peter Hilton of Case Western Reserve University and Battelle-Seattle Research Center, was created to study the "mismatch between college mathematics curricula and opportunities for employment." The committee concluded in its 25-page report, "The Role of Applications in the Undergraduate Mathematics Curriculum," that the principal source of the problem was mathematicians' attitudes — "a strong and pervasive tendency towards scholasticism." To reverse this trend the committee put forward a platform of 14 recommendations that it hopes will influence national policy toward mathematics education in the 1980s.

Chief among these are recommendations that encourage colleges to reorient their mathematics curricula to be outward rather than inward directed; to require minors in nonmathematical subjects, as well as work in computing that is closely tied to mathematics courses; and to offer experience in applications of mathematics as an integral part of every program for the major in mathematical science. Implementation details concerning these curricular recommendations are currently under study by the Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America. □

## Fluoride effective against caries?

The apparent reduction in dental caries in children using fluoride toothpaste or tablets compared with controls using neither, which has emerged in a number of recent studies, may be an artifact introduced by dissimilar samples of children in each group. In a large study carried out recently in Holland, Dutch scientists found essentially no reduction in caries when the fluoride users and non-users had been carefully matched.

This surprising conclusion was announced last month by a group led by T. J. Tijnstra from the University of Groningen and the Utrecht Health Organisation TNO at the Sixth International Conference on Social Science and Medicine, held in Leeuwarden, Holland. Tijnstra has always felt dissatisfied with past fluoride surveys because of the high rate at which children dropped out, leaving a final sample invariably motivated to good dental behavior.

He determined to design a study in which the two groups of children were as closely matched as humanly possible. He began with 583 randomly selected children born in 1961 and now in the schools of Leeuwarden, a town in northern Holland that does not have fluoridated water. About 95 percent of the children and their mothers agreed to take part in the study. The children were all given detailed dental examinations and they and their mothers completed lengthy questionnaires. Children who had taken fluoride tablets for eight years scored 16.6 on their dental index (a measure of the proportion of teeth missing, filled or suffering decay) compared with 19.0 for children who used no fluoride. Fluoride toothpaste users scored 17.5, while children using both supplements scored 14.2.

This scoring was suspect, however, because Tijnstra's group found that those children with eating and teeth cleaning habits most likely to cause caries were the very ones who tended not to use fluoride at all. The scientists therefore compiled two samples of children who were as near identical as possible with regard to father's occupation, candy consumption and toothbrushing habits. The reduction in caries among fluoride users vanished. Children who used either fluoride toothpaste or tablets scored essentially identical dental indices as the non-users. Only in the case of the few children who used both toothpaste and tablets did a small reduction remain.

Tijnstra's conclusion is that fluoride products are of dubious value in reducing dental caries. Such a conclusion, however, is not likely to be widely accepted (especially by producers of fluoride toothpastes) without confirmation of the results by other researchers. □