1973), who pointed out that when metal and semiconductor are placed in intimate contact their surfaces will both be changed, particularly by the ability of electrons to penetrate from the metal into the surface of the semiconductor by tunnelling into the forbidden energy gap. This effect changes the charge distribution and therefore the electric field at the interface in a way that could explain qualitatively quite a large body of results. Gradually it has become clear, however, that quantitatively the effects predicted are not large enough to explain the number nor the spatial distribution of surface states. The results of Thanailakis (*J. Phys. C.* **8**, 655; 1975), are amongst the most important in establishing this point.

We come now to the latest suggestion, backed by extensive and impressive experimental data from Spicer and his group at Stanford University. The latest paper (Spicer *et al. Phys. Rev. Lett.* **44**, 420; 1980) spells out the mechanism they propose for barrier formation in a number of compound semiconductors. These are materials which exhibit no intrinsic surface states within the forbidden energy gap. That is, on the cleaved surfaces of these materials the Fermi Energy is found, by photoelectric emission measurements, to be the same as that in the bulk, showing that there is no electric field in the semiconductor surface. The evaporation of metal, or the adsorption of oxygen, on these surfaces is found to change this situation and to give rise to surface states and, consequently, to electric fields which move the band edges relative to the Fermi Energy. The most important feature of their results is that the energy levels so produced are specific to the semiconductor and not to the material deposited. Spicer's explanation of this depends on the large heat of adsorption of materials on semiconductor surfaces, about 3 eV per atom according to some measurements. This is enough to produce lattice defects such as vacancies or more complex entities in and near the semiconductor surface, and it is these defects, Spicer claims, which control the potential barriers. It is perhaps early to say that the full picture has now been revealed, but it is clear than an important new step has been taken. It will lead to a better appreciation of what is possible in the production of metal-semiconductor contacts with tailored properties as well as improving our understanding of interface physics. □

Vaccination against paramyxoviruses

from A.J. McClelland

PARAMYXOVIRUSES are now known to be a major cause of respiratory illnesses but, despite the importance of these diseases, little progress has been made in their control. Live virus vaccines are available for only two paramyxovirus diseases (measles and mumps) and failures of these vaccines resulting in severe complications, such as modified and atypical measles, have been reported (Chatterji & Marikad *J. Am. Med. Assoc.* **238**, 2635; 1977). Inactivated virus vaccines against the measles virus and other paramyxoviruses, such as the respiratory syncytial (RS) virus and the parainfluenza viruses, have had limited success and have sometimes induced severe forms of the illnesses they are supposed to prevent (Kim *et al. Am. J. Epidem.* **39**, 422; 1969; Welliver *et al. Arch. Int. Med.* **137**, 39; 1977). The unusual complications that sometimes occur after paramyxovirus vaccination have been attributed to an aberrant immune response, but it is not known how or why such a response occurs.

New light has recently been shed on the problems associated with paramyxovirus vaccination by Merz *et al.* (*J. exp. Med.* **151**, 275; 1980) who have investigated the infectious spread of one paramyxovirus, SV5, using monospecific antibodies to the two SV5 surface glycoproteins. These authors report that SV5 can be disseminated in two ways: (1) release of infectious virus from infected cells and (2) cell fusion, in which no infectious virus need be released. They found that antibodies to the viral haemagglutinating and neuraminidase (HN) glycoprotein prevent the spread of infection by the release of virus particles, but do not prevent the spread of infection by cell fusion, whereas antibodies to the viral fusion (F) glycoprotein prevent the spread of infection by both cell fusion and release of infectious virus. The results obtained by Merz *et al.* emphasize the importance of the F glycoprotein in the dissemination of SV5.

Their findings, together with the earlier observation that vaccination elicits a weak F antibody response, or fails to stimulate F antibody production altogether (Norrby & Gollmar *Infect. Immun.* **11**, 231; 1975), suggest a possible explanation for the severe complications that sometimes result from paramyxovirus vaccination. In a person vaccinated against measles, for example, exposure to the measles virus could result in a disseminated infection because of the lack of F antibodies and the ability of the virus to spread from cell to cell by cell fusion. As the infection spreads, syncytium formation would take place and the antigen load would increase. Released virus particles would be neutralized by the vaccine-induced H antibodies (the measles virus equivalent of SV5-induced HN antibodies), and would provide additional antigenic stimulation resulting in an anamnestic response to the H antigens to which the vaccine provided the primary response. In these conditions, immune complexes composed of the antigen-producing syncytium and H antibodies could form, activate the complement system and result in inflamation and tissue necrosis. Alternatively, antibody-mediated cytotoxicity might cause the observed inflamation without complement activation. Either process could account for the immunopathological reactions that have been observed in some people given RS or measles vaccines.

In addition to providing an insight into the possible mechanisms involved in the complications associated with paramyxovirus vaccination, the work of Merz *et al.*, together with earlier work by Waldman and Ganguly (*J. infect. Dis.* **130**, 419; 1979) and McIntosh *et al.* (*J. infect. Dis.* **138**, 24; 1978), among others, suggests an approach to paramyxovirus vaccination that may be both safe and effective. Merz *et al.* show that pure F glycoprotein would be the ideal immunogen for a paramyxovirus vaccine and the earlier studies suggest that the most effective way of administering this immunogen would be directly into the lung as an aerosol. The advantage of such local immunization is that it would stimulate secretory IgA, which does not activate the complement system or antibody-mediated cytotoxicity, and would thus avoid the immunopathological consequences resulting from stimulation of IgG antibodies. The disadvantages of the suggested approach are the difficulty of developing high IgA titres and the short duration of immunity. However these problems are not insurmountable. Morein *et al.* (*Nature* **276**, 716; 1978), for example, were able to prevent a lethal infection of mice with Semliki Forest virus by vaccinating the mice with a micellar aggregate of the virus spike protein. Interestingly, they found that the monomer form of the protein solubilized with detergent was much less effective than the aggregated protein. Those results suggest that protective and lasting immunity to paramyxoviruses might be stimulated by administering the F glycoprotein as an aggregate rather than in the solubilized form. Alternatively, the F glycoprotein could be administered together with an immunoadjuvant, such as the purified active component of Freund's adjuvant, N-acetyl-muramyl dipeptide (Azuma *et al. Infect. Immun.* **14**, 18; 1976; Chedid *et al. Proc. natn. Acad. Sci. U.S.A.* **73**, 2472; 1976), which does not produce the abscesses associated with the complete Freund's adjuvant. Using either approach, it might be possible to introduce pure F glycoprotein into the lung as an aerosol and stimulate immunity without adverse side effects. If so, it would be an important step towards controlling respiratory infections.

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