biology of freshwater fishes in Ireland, of which this is the latest.

Kennedy and Fitzmaurice report that gudgeon occur commonly in the stomachs of pike in the Lee and Blackwater systems, and that trout in the former river also eat them. In one of the newly built Lee reservoirs the gudgeon population greatly expanded between 1959 and 1963, and between 40 and 80 per cent of the trout in the reservoir were eating them. This figure has fallen to almost zero since the gudgeon population declined.

This study thus shows that the gudgeon has some importance as a food fish for trout, and to a lesser extent for pike. The authors, however, make no comment on any competition that it may offer to the former species, a far more valuable fish. Young trout in small streams eat substantially the same groups of invertebrates as does the gudgeon, and therefore there may well be a considerable degree of competition.

PESTICIDES

Resistance in Arthropods

from a Correspondent

AN important aspect of the battle against hunger and suffering, especially in the developing countries, is the control of arthropod pests that attack food before or after harvest or are vectors of debilitating diseases. When few chemicals are available to control a particular pest the development of strains resistant to one or more of these compounds can have serious consequences. Scientists involved in pest control are conscious of the dangers and at a meeting in London of the Pesticides Group of the Society of Chemical Industry on October 16 they took stock of the situation and discussed future prospects.

Professor J. R. Busvine (London School of Hygiene and Tropical Medicine) reviewed the progress made during the past 25 years. Methods that are simple, reliable and reproducible under adverse conditions in the field have been developed to assay a pest for resistance. Laboratory studies can then establish the range of pesticides that the pest can tolerate—it is alarming that an insect strain can develop resistance not only to the compound to which it was subjected but also cross-resistance to chemically unrelated structures it has never encountered. The pick-up, metabolism (activation or detoxication) and excretion of the insecticide in resistant and susceptible strains are investigated. Frequently lack of control in the field occurs when several mechanisms reinforce each other and they may be differentiated by genetic studies on the resistant strains.

The closed environment of a glasshouse is ideally suited to the build-up of resistance. In commercial glasshouses in the United Kingdom strains of the aphid *Myzus persicae*, red spider mite, leaf miners and whitefly occur that are resistant to many pesticides. Frequency of harvesting further limits the choice of compounds. Dr N. W. Hussey (Glasshouse Crops Research Institute) stated that he and his colleagues aim to prolong the commercial life of pesticides by integrating their use with biological control measures. The effect of pesticides and fungicides on the beneficial species must be considered and, ironically, two of the systemic fungicides more satisfactory on this score have potential problems with the arrival of strains of tolerant fungi.

Another aspect with specific problems is the control of cattle ticks. Mr E. C. Wilmshurst (Thurgarton Research Station) stressed that the methods of pesticide application normally used—driving the cattle through dips or sprays—are unsatisfactory because the dose a beast receives cannot be accurately controlled. Tolerance was first encountered to sodium arsenate but in the past 20 years cases of resistance and cross-resistance to chlorinated hydrocarbons, carbamates and organophosphates have been reported. Though resistance to a given compound can develop in several continents over a period of about two years the outbreaks are independent and localized. A new method of application is required; a "pour-on" technique with 100 millilitres per beast of an experimental compound, which is systemic in cattle, shows promise.

Mr C. E. Dyte (Pest Infestation Control Laboratory) stated that surveys of insects of stored products indicate that eleven species of Coleoptera and five of Lepidoptera show resistance to at least one group of insecticides. Genetic studies have not been made to provide the crucial evidence but observations on the effect of synergists, the relationship between tolerance and chemical structure and metabolic studies in susceptible and resistant strains, show there are several mechanisms involved. Metabolic factors are implicated and may account for the resistance of a strain of *Tribolium confusum* to synthetic analogues of a juvenile hormone and to several other types of insecticides.

Professor Busvine had stressed the need for collaboration between zoologists, geneticists and biochemists. An excellent example of such cooperation is provided by scientists at Rothamsted Experimental Station, three of whom summarized their recent work. Dr R. M. Sawicki, using genetic markers, has isolated strains of *M. domestica*, showing single resistance factors, the mechanisms of which could be established, and re-linked them by crossbreeding. Flies which showed resistance to organochlorine, organophosphorus and carbamate insecticides revealed the wide range of mechanisms that may operate. Mr A. W. Farnham reported similar studies on *M. domestica* resistant to natural pyrethrum extract (strain *NPR*) or to resmethrin (strain *104*), a synthetic pyrethrin. These strains were selected in the laboratory—most cases in the field of resistance to the pyrethrins have occurred as cross-resistance when other types of insecticide had been used. Dr A. H. Devonshire discussed the results of his biochemical studies on resistance in *M. domestica* and *M. persicae*. The co-factor requirements and substrate specificities of enzymes isolated from strains susceptible or resistant to various insecticides help to differentiate the mechanisms involved. He noted the role of oxidases in activation or detoxication of various pesticides. These

Mica Sheets and Molecular Interactions

IN next Monday's *Nature Physical Science* (November 20) Bailey and Daniels describe an elegant experiment by means of which they have measured some of the parameters defining the force of attraction between two pieces of mica in close proximity.

The essence of their device is a pair of narrow strips of mica, each some 5 μm thick, which touch each other near one end and are held apart at the other. Bailey and Daniels measured the precise separation profile of this delicate arrangement by multiple beam interferometry.

Theoretically the attraction between the two pieces of mica can be expressed in terms of calculable parameters like the Madelung constant and the number of ion pairs per unit area. The total force is, of course, made up of ionic and dispersion forces, the former of which contribute about ten times as much to the overall surface energy as the latter. Other parameters in the expression for the attraction were then altered until the calculated effect on two (non-interacting) sheets was as close as possible to the effect of real forces.

Bailey and Daniels particularly draw attention to the fact that one of the "best-fit" parameters, the so-called equilibrium contact separation, turns out to be 7 nm which is almost exactly the thickness of two monomolecular layers of water molecules.