possible. This gives an activation energy of 0.49 ± 0.03 eV, significantly lower than estimates of the activation energy for volume diffusion of 0.60 eV (ref. 3) and 0.62 ± 0.04 eV (ref. 6).

Petit *et al.*[1] discount the possibility that dissolved impurities slow grain growth[2] by noting that coastal sites with high concentrations of soluble impurities (especially NaCl) plot near (although slightly below) the same Arrhenius trend as inland sites with lower concentrations of impurities. But the coastal sites[1,4] at −19 and −17 °C are warmer than the NaCl–H_2O eutectic (−21 °C). With increasing temperature above the eutectic, impurity drag is reduced to zero and enhanced boundary migration begins during a transition from solid- to liquid-phase boundaries. Experimental results from Jellinek and Gouda[7] show that this transition occurs between −23 and −10 °C at 10^{-2} M NaCl, and results from de Achaval *et al.*[8] show that 10^{-2}–10^{-4} M NaCl speeds grain growth at −16 °C and above; natural concentrations of soluble impurities are 10^{-5}–10^{-6} M in coastal sites and 10^{-6}–10^{-7} M inland[1]. Therefore, it is possible that inland sites experience significant impurity drag, but that warm coastal sites are near the transition and experience little impurity drag; further study is warranted. The temperature 'memory' proposed by Petit *et al.*[1] thus cannot explain the small grain sizes in Wisconsinan ice, but available data are consistent with an impurity-drag model.

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PETIT *ET AL.* REPLY—In polar deep ice cores, the climatic change between the Holocene and the last glacial maximum, as depicted from the stable isotope content, is accompanied by modifications in crystal size and impurity content. We have interpreted[1] the change in crystal growth rate mainly as a result of a climatic (temperature) effect whereas Alley *et al.* (ref. 2 and above) attribute it to the effect of soluble impurities such as NaCl. Here we discuss the stability of extrinsic interstitial defects, the value of the activation energy for the growth pricess, and the effect of the soluble impurity content.

First, our model basically assumes a built-in memory of the thermal conditions prevailing in the top layers of the firn through defect formation in the ice crystal lattice. Our assumption concerning the formation of extrinsic defects through an ageing effect in the top few metres of snow is supported by several physical measurements[10,11] (dielectrical and micromechanical damping behaviour of ice). These extrinsic defects (interstitials or more complex defects) are likely linked to structural defects such as sub or grain boundaries[11]. The mobility of these defects could control the migration of boundaries[1]. Alley *et al.* discuss the diffusion coefficient that concerns the diffusion of self-interstitials, but not the diffusion of interstitials associated with boundary migration. The structure of ice crystals after ageing could correspond to a lower free energy[11]. It should therefore be stable as long as there is no nucleation of new crystals during dynamic recrystallization, and is preserved in deep-ice core records.

Second, Alley *et al.* obtain 0.49 eV for the activation energy deduced from the Arrhenius plot of available data. This value differs from ours because we excluded the data from Plateau Station (−57 °C) because of its highly uncertain chronology. In any case, with a value of 0.49 eV, the temperature change between the Holocene and the last glacial maximum estimated by our model would be only slightly affected, increasing by about 15 per cent.

Third, Alley *et al.* assert that above the NaCl–H_2O eutectic temperature (about −21 °C), the impurity drag effect is reduced to zero with the formation of a liquid phase at grain boundaries. But if we assume, as did Alley *et al.*[2], that Na^+ and Cl^- dissolve in the ice lattice and that grain boundaries are not saturated, the formation of the eutectic below −21 °C and of a liquid phase above would not be expected. Recent work[12] on the localization of impurities in a polar ice sample with 320 parts per 10^9 (p.p.b.) Cl^- content (Dollman, Antarctica) shows that no Cl (less than 1 per cent) is at triple junctions, even though the temperature *in situ* is as high as −16.7 °C. Any liquid present in polycrystalline ice should be preferentially at triple junctions[13]. As grain growth data from coastal Holocene ice at − 19 °C and − 17 °C (with 200–400 p.p.b. Na) are in accordance with data from inland sites at lower temperatures (with 20–40 p.p.b. Na), the drag impurity effect cannot be used to explain grain growth in polar ice[1].

In conclusion, on the basis of the limited data available, our interpretation remains valid, but the grain growth observations from sites with very different impurity concentrations do not support the drag impurity model of Alley *et al.*[2].

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Sexual selection and predation risk in guppies

SIR—Breden and Stoner[1] present the results of an experiment apparently showing that predation risk determines female preference of male colour patterns in wild guppies; guppies from places with low predation apparently prefer brighter model fish whereas those from high predation apparently prefer duller models. Apart from the general implications for sexual selection theory, these results could explain the remarkably rapid increase to predation in my own experiments[2], because sexual selection and predation would both favour less conspicuous colour patterns under high predation. Unfortunately, there are some serious flaws in the experimental design, as well as some problems of interpretation, which make the interpretation concerning sexual selection questionable. Here, I point out the difficulties of experiments of this nature and suggest ways in which to demonstrate this potentially very interesting phenomena.

In Breden and Stoner's experiment[1], the males to be chosen by females were models made from painted balsa wood, and were 4.8 cm total length by 1.3 cm high, which is as much as four times larger than real males[3,4]. Therefore, female guppies may respond to these models not as super-normal guppy stimuli but as potential predators such as *Rivulus*, *Hemibrycon* and *Astyanax*, which are about the same size[3,5] as the models.

In addition, Breden and Stoner placed an aerator near the brighter model, and not near the dull one so the brighter one moved more. It is unfortunate that this experiment was not properly controlled with both models moving equally; females from high-predation stocks could have been more frightened of the brighter, more rapidly moving models, and so 'preferred' the duller models. Females from the low-predation stocks were less frightened by the apparent predators (as they normally do not experience predation[3,5,6]), and may even have been attracted by the colours. This is consistent with several studies of fright and other anti-predator behaviour in guppies, which is also heritable (refs 7–10, and P.H. Luyten, unpublished thesis). Therefore, the results