

Reproductive biology

Forming an attachment

Before a sperm can successfully fertilize an egg, it must bind to the egg's outer layer, the zona pellucida. This attachment is probably highly specific, as sperm will only recognize eggs from the same species. So what controls sperm-egg attachment? Writing in *Cell* (114, 405–417; 2003), Michael A. Ensslin and Barry D. Shur take a step towards answering this question — and their findings could offer clues to why some males with apparently 'normal' sperm are infertile.

In a hunt for egg-binding molecules, the authors looked at a protein from mouse testes, which they named SED1. This protein was a likely suspect because it was similar to a protein from boar sperm that had previously been shown to interact with components of the zona-pellucida. They found that



SED1 was located on the surface of mouse sperm — a good start. But more interesting was the finding that antibodies against SED1 blocked sperm-egg binding.

Of course, what happens in a test tube is not always important in animals, so the authors looked next at the effect of eliminating SED1 in

mice. They found that genetically engineered mice that lacked SED1 were much less fertile than normal mice. And although the sperm from these mice moved normally and were produced in the usual quantities, they failed to bind to eggs — proof that SED1 is indeed needed for sperm-egg binding. **Clare Thomas**

Although this approach does not provide a fully independent check on the data, it might eventually prove useful in diagnosing heat fluxes and other dynamic changes required to create such a pattern.

Additional models extend the GLAMAP-2000 results from the sea surface into the ocean interior. An AGCM that uses the new maps of sea surface temperature as a boundary condition drives an ocean general circulation model (OGCM) that produces a substantial cooling of water masses a few hundred metres below the sea surface, especially in the Southern Hemisphere¹³. Return of these chilly subpolar water masses to the sea surface at low latitudes provides a mechanism for cooling along the eastern boundary and the Equator, and points to possible interactions between low-latitude and high-latitude controls of climate. The OGCM also indicates that the deep sea was dominated by cold waters of Antarctic origin, although this finding depends on the assumed rate of sea-ice formation. Salt excluded from relatively fresh sea ice makes surface waters more dense, and thus more likely to sink.

A surprising result of the model is a poleward shift of the westerly winds and Antarctic Circumpolar Current during the ice age, in spite of known topographic steering of this current and an apparent expansion of cold water masses from the Southern Ocean towards the Equator. The inferred northward

extent of the cold Antarctic water masses suggests a possible deflection of Southern Ocean waters along the Pacific coast of South America, although this movement was not so large as to restrict the flow of relatively warm waters around South Africa⁷, an important conduit for global transports of heat and salt.

Recent experiments with coupled atmosphere-ocean models^{14–17} attempt to explain the glacial world while relying on temperature reconstructions only for verification of the model results. So far, the available coupled models produce divergent simulations of both the magnitude and direction of change in key features such as subtropical sea surface temperatures (ranging from slight warming¹⁴ to extensive cooling¹⁷) and deep-water formation in the North Atlantic (increased¹⁶ or decreased^{15,17}). Although the disagreements among the models, and between the models and data, underscore the need for caution in interpreting both 'hindcasts' of past climates and forecasts of future climates, they also point to the power of using a combined data-model approach to test, and improve, the models.

Finally, there is the question of how good the temperature data are. Conflicts occur in some areas between the temperatures reconstructed from fossil plankton species, and those from geochemical proxy measurements, such as the Mg/Ca ratio in foraminifera and an index, known as $U_{37}^{K'}$, based on traces of organic molecules

produced by certain plankton species. In the GLAMAP-2000 data set, discrepancies between the temperature proxies are especially acute for the Namibian upwelling system⁸ and the eastern equatorial Atlantic⁹. Similar discrepancies appear in some areas of the Pacific, leading to debate about whether the mean state of the glacial ocean was more akin to that of a modern interannual La Niña^{17,18} or El Niño^{19,20} event (cold or warm eastern equatorial region, respectively), or was something entirely different¹⁰.

The statistical basis of the transfer-function approach makes it best able to circumvent biases associated with seasonal plankton blooms. But in some cases the assumption that modern spatial variability serves to calibrate past biotic variations in terms of climate may break down. Culture experiments attest to the value of the geochemical tracers. But in the real world, organisms near their limits of thermal tolerance tend to adjust their depth or season of peak production, which would give the false impression of little or no temperature change in the chemical tracers.

The particular challenge for the coming years is to find a reliable means of understanding and correcting for the biases in each method of estimating temperature. With that, the resulting best estimate of large-scale climate changes will inform modelling experiments and reveal the primary processes responsible for global environmental change. ■

Alan C. Mix is at the College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Oregon 97331-5503, USA.
e-mail: amix@coas.oregonstate.edu

- Sarnthein, M. *et al. Paleoceanography* published online 3 May 2003 (doi:10.1029/2002PA000769).
- CLIMAP. *Geol. Soc. Am. Map Chart Ser.*, MC-36 (1981).
- Mix, A. C., Bard, E. & Schneider, R. *Quat. Sci. Rev.* **20**, 627–657 (2001).
- Nørgaard-Pedersen, N. *et al. Paleoceanography* published online 30 July 2003 (doi:10.1029/2002PA000781).
- Sarnthein, M., Pflaumann, U. & Weinelt, M. *Paleoceanography* published online 11 June 2003 (doi:10.1029/2002PA000771).
- Weinelt, M. *et al. Paleoceanography* (in the press).
- Gersonde, R. *et al. Paleoceanography* published online 23 July 2003 (doi:10.1029/2002PA000809).
- Niebler, H.-S. *et al. Paleoceanography* published online 27 August 2003 (doi:10.1029/2003PA000902).
- Pflaumann, U. *et al. Paleoceanography* published online 2 August 2003 (doi:10.1029/2002PA000774).
- Feldberg, M. & Mix, A. C. *Mar. Micropaleont.* **44**, 1–29 (2002).
- Cane, M. *Science* **282**, 59–61 (1998).
- Grieger, B. & Niebler, H.-S. *Paleoceanography* (in the press).
- Paul, A. & Schäfer-Neth, C. *Paleoceanography* published online 9 July 2003 (doi:10.1029/2002PA000783).
- Kitoh, A. & Murakami, S. *Paleoceanography* published online 11 September 2002 (doi:10.1029/2001PA000724).
- Shin, S.-I. *et al. Clim. Dynam.* **20**, 127–151 (2003).
- Hewitt, C. D., Stouffer, R. J., Broccoli, A. J., Mitchell, J. F. B. & Valdes, P. J. *Clim. Dynam.* **20**, 203–218 (2003).
- Kim, S.-J., Flato, G. M. & Boer, G. J. *Clim. Dynam.* **20**, 635–661 (2003).
- Martinez, I., Keigwin, L., Barrows, T., Yokoyama, Y. & Southon, J. *Paleoceanography* published online 14 May 2003 (10.1029/2002PA000877).
- Koutavas, A., Lynch-Stieglitz, J., Marchitto, T. & Sachs, J. *Science* **279**, 226–229 (2002).
- Stott, L., Poulsen, C., Lund, S. & Thunell, R. *Science* **279**, 222–226 (2002).