induced in the DNA by the unwinding of the DNA during replication. Alternatively, or additionally, the DNA may need to be made negatively superhelical for DNA replication to be initiated. Negatively superhelical DNA is required for the initiation of replication of the bacteriophage ϕX174 replicative form DNA *in vitro* because the ϕX174 gene A protein, which must nick the DNA to intiate replication, does not act on relaxed DNA (Marians *et al. Proc. natn. Acad. Sci. U.S.A.* **74**, 1965; 1977).

Surprisingly gyrase seems to be required for the replication of the linear DNA of the phage T7 *in vivo* but not *in vitro* (DeWyngaert & Hinkle *J. Virol.* **29**, 529; 1979). The most likely explanation is that in the cell the DNA is collapsed into a compact structure as a result of its interaction with cellular molecules, whereas in its isolated form *in vitro* one end of the duplex is free to rotate relative to the other end and so superhelical twists cannot build up in the molecule.

McCarthy (*J. molec. biol.* **127**, 265; 1979) has discovered that the T4 DNA-delay mutants (*39,52,60*) require DNA gyrase for replication as they are unable to replicate in the presence of novobiocin or coumermycin in sensitive, but not drug-resistant, cells. Wild type T4 was not dependent on gyrase function, presumably because the products of one or more of the above genes form an enzyme that provides an equivalent function. From the kinetics of DNA synthesis under conditions of gyrase inhibition McCarthy deduced that the activity was required for the initiation of 'growing points' but not for the actual DNA elongation process.

On the assumption that transcription and recombination require local unwinding of the DNA it is hardly surprising that in certain cases gyrase seems to be required for both. However, the weight of the evidence suggests that gyrase is only required for transcription from some promoters (Smith *et al. Nature* **275**, 420; 1978). It is not obvious why. Harking back to the *in vitro* studies on integrative recombination in phage lambda from which the existence of gyrase was inferred it seems likely that the requirement for gyrase in recombination may be a consequence of the need for negatively superhelical DNA for this reaction, as well as for its role in DNA unwinding (Mizuuchi *et al. J. molec. Biol.* **121**, 375; 1978). One explanation for the requirement for negatively superhelical DNA is that the negative superhelical turns facilitate the uptake of pieces of single-stranded DNA to form partially triple-stranded structures. (Beattie *et al. J. molec Biol.* **116**, 783; 1977).

It is relevant to note that those DNA metabolic processes that are coupled to gyrase action become directly dependent on the ATP content of the cell, and a high ATP content at that, since the K_m of gyrase for ATP is of the order of 300 μm. If the cell cannot generate adequate supplies of energy the negative supertwisting of the DNA will rapidly disappear. With its disappearance those reactions which depend on having a negatively superhelical DNA substrate will not take place. The advantage of this as a control point in the prokaryotic cell is self-evident. Negative supertwisting, or its absence, is a signal transmitted throughout the entire DNA molecule, or at least that section of it that behaves as a topological unit.

So far gyrase has not been found in eukaryotic cells and there is no reason to expect it. The eukaryotic nicking-closing enzyme is sufficient to remove the positive superhelical twists induced in the DNA during replication. the superhelical twists present, for example, in purified SV40 DNA are accounted for by the number of nucleosomes in the DNA. (Each turn of the DNA around a nucleosome is approximately equivalent to one superhelical twist). Consequently eukaryotic DNA is not under an unwinding stress resulting from the presence of negative superhelical twists and this could be a partial explanation for its being replicated more slowly than prokaryotic DNA. □

Oceanic heat flow, lithosphere age and thickness

from Geoff Brown

THE systematic decrease of measured heat flow with increasing age of oceanic lithosphere was well documented by the classic work of Sclater and Francheteau (*Geophys. Jl. R. astr. Soc.* **20**, 509; 1970). But in more recent years a definitive relation has been sought as proof that plate thickness increases as the square root of time. This relation follows naturally from the theory of conductive heat losses which lead to the cooling, contraction and basal freezing of oceanic lithosphere as it moves away from the zone of spreading.

A thermal model relating plate thickness, age (<120 Ma) and heat flow was summarised by Parsons and Sclater (*J. geophys. Res.* **82**, 803; 1977) who cited evidence from the North Pacific that q varies as $t^{-1/2}$ (q = heat flow, t = age). However, their data were limited to crust of age <20 Ma and >70 Ma because the reliability of heat flow and/or age control was inadequate for other times and places. In the main, uncertainties arose from the highly scattered heat flow values caused by hydrothermal disturbance in layer 1. Sclater and Crowe (*J. geophys. Res.* **84**, 1593; 1979) have taken an important step forward by measuring heat flow at 17 stations close to magnetic anomaly 13 (age = 35 Ma) on the Reykjanes ridge. By using piston cores and measuring thermal gradients across intervals down to 12 m in sediment they were able to isolate non-linear gradients above 5 m (sediments affected by recent changes in ocean bottom water temperature) from 'remarkably linear' gradients below 7.5 m. In the former case, anomalously high, non-equilibrium temperature gradients were attributed to recent changes in seawater temperature due to changes in the velocity and temperature of Norwegian Sea overflow water. The stable gradients below 7.5 m ranged from 69.9 to 102.2 mW m^{-2}, giving a mean heat flow for anomaly 13 of 82.9 ± 10.1 mW m^{-2}. The variations in these data are real in that they exceed the precision of measurement and an excellent inverse correlation, local to the survey area, was found between heat flow and depth of sediment overlying a seismic basement ridge. This suggested that either heat flow is refracted because of the contrasting thermal conductivity between layer 1 and layer 2 (that is, due to the insulating effect of the sediments) or that the interface between the layers is isothermal due to hydrothermal convection in the deeper layer: both explanations can account for the observed local variations in heat flow.

Sclater and Crowe have shown that reliable conductive heat flow data for oceanic lithosphere can be obtained by detailed and critical analysis of down-core temperature variations. Moreover, their results from the Reykjanes ridge fall on the $q/t^{-1/2}$ graph for Pacific data of other ages and provide further support for the thermal model of lithospheric thickening in proportion to the square root of age.

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A hundred years ago

Glow-worms

Shelley sings of a "glow-worm golden in a dell of dew," but last night, at 10 o'clock, while travelling on a bridle path among the bleak lonely mountains of Tynron, Dumfriesshire, bearing up against a high wind with cold rain, I espied three glow-worms shining among the grass and ferns. I had seen them in the same locality before, but scarcely expected to have noticed them in such ungenial weather when summer has with us scarcely yet begun. J. S.
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