

NUCLEAR MAGNETIC RESONANCE

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One of the great challenges of contemporary Nuclear Magnetic Resonance (NMR) spectroscopy is the application of the technique to highly complex problems in biology. No other form of spectroscopy can contribute to the elucidation of the structure, function and dynamics of biomacromolecules at the atomic level. Our research is focused on the following three broad areas: the structure of complexes between DNA and anticancer antibiotics; the structure of unusual forms of DNA that have biological significance; and the structure and function of moderately sized proteins with a special focus on proteins that bind to DNA and RNA. Work has just been completed on structural studies of a large protein-protein complex and work is continuing on the structures of two small biologically important human proteins. The investigation of the interaction of spermine and calothrixin with various forms of DNA continues to give surprising results. As our expertise in macromolecular structure determination increases we intend to tackle more demanding structural problems. In the near future, we will attempt the structure determination of the *N*-terminal and *C*-terminal domains of a 42 kDa protein that is over expressed in the cells of early breast cancer tumours and the structure determination of an RNA-binding protein. The ultimate goal of this work is to use the structure of the protein to design drugs that may be used to block the progression of the tumour cells. The major theme of our work is to deduce the function of biological molecules and complexes from knowledge of their structure and dynamics at the atomic level.

NMR Studies of the Interaction of Spermine with Oligonucleotides

Spermine, an aliphatic polycationic molecule found in all cells, plays an essential role in cell growth and differentiation. At present, there is no thorough understanding of how polyamines exert their physiological effects. Spermine is known to interact both with DNA and with proteins, yet the details of these interactions and the molecular basis of the biological function of spermine are poorly understood. There is evidence in the literature that spermine interacts with different forms of DNA in distinct and divergent modes. We have confirmed this and have characterised the complexes of spermine with duplex B-DNA and G-DNA using a specifically ^{13}C -labelled spermine and advanced NMR techniques to take advantage of the specific isotope label on spermine. Quantitative analysis of the field dependence of ^{13}C T_1 and T_2 relaxation times and homonuclear and heteronuclear NOEs have been used to characterise the dynamics of spermine in the presence of different forms of DNA. The fast internal motion of spermine is slowed by two orders of magnitude on binding to all forms of DNA. Only in the case of folded DNA quadruplexes is there evidence of a slower motion associated with overall tumbling of the macromolecular structure and an exchange process between two or more different binding sites. *(With K Clayton)*

Novel Antibiotics and DNA

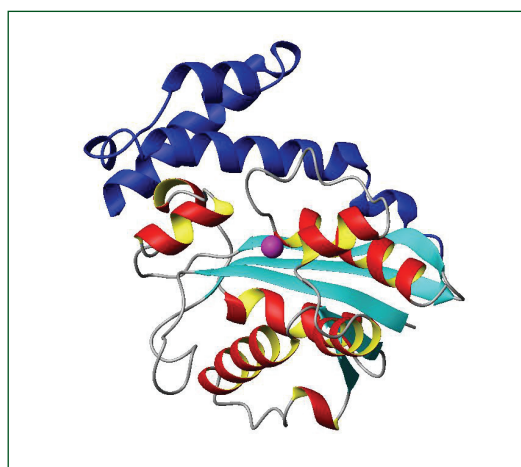
Calothrixin A and B are novel pentacyclic metabolites from cyanobacteria that exert growth-inhibitory effects at nanomolar concentrations against rapidly proliferating cell cultures. The binding properties of the calothrixins and their synthetic analogues with various structural forms of DNA are under investigation by NMR, circular dichroism and fluorescence. Calothrixin binds to linear quadruplexes as shown by UV, CD and NMR spectroscopy. *(With E A Owen, R W Rickards, and C Chai, M Waring [Dept Chemistry, ANU], G D Smith [BaMBi, ANU])*

HuR, a Protein that Modulates the Stability and Lifetime of mRNA

Hu proteins control the post-transcriptional expression of proteins by binding to and modulating the decay rates of mRNA. We have cloned a splice variant of one of these Hu proteins, HuR, with the aim of pursuing structural studies. (With N E Dixon, P Prosselkov, and C C Benz, G Scott [Buck Institute for Age Research, USA])

Interaction of the θ -subunit and the ϵ -subunit of DNA Polymerase III

The catalytic core of *Escherichia coli* DNA polymerase III contains three tightly associated subunits (α , ϵ , and θ). The refinement of the three-dimensional structure of the θ -subunit was completed by the NMR group. The θ -subunit has three α -helices in the *N*-terminal two thirds of the protein that fold to form a three helix bundle. As part of a program aimed at understanding the molecular mechanism of the core, we have set out to investigate the association of the θ - and ϵ -subunits. The structure of the θ -subunit bound to ϵ has been refined using an innovative technique that combines NOE restraints with distance and orientation restraints calculated from a paramagnetic centre located in the active site of ϵ . We have mapped the binding surface of ϵ on θ to a hydrophobic patch on θ using advanced NMR techniques. The structure of the complex between θ and ϵ has been assembled using the same paramagnetic restraints that were used to refine the structure of ϵ . The final structure and alignment is shown below. (With N E Dixon, S Hamdan, G Otting, A-Y Park, G Pintacuda, T K Ronson, and S E Brown [CSIRO Entomology])



The three-dimensional structure of the $\theta\epsilon$ complex. θ is shown in blue and the lanthanide ion in the catalytic pocket of ϵ is shown as a magenta ball located at the ϵ active site.

ESX, a Protein Over Expressed in the Early Stages of Epithelial Breast Cancer

ESX is a protein that belongs to the Ets family of transcription factors. Ets proteins exhibit diverse roles in development, cell-differentiation and tissue-specific gene expression and are implicated in cancers such as acute myeloid leukemia and Ewing's sarcoma. The ESX transcription factor may have a role in the activation of the HER2/neu oncogene, which is over expressed in over 40% of breast tumours. To this end we have over expressed ESX and its *C*-terminus containing the two DNA-binding domains. Attempts will be made to crystallise these proteins. This project is supported, in part, by a Yamagiwa-Yoshida travel grant from the International Union against Cancer. (With N E Dixon, P Prosselkov, and C C Benz, G Scott [Buck Institute for Age Research, USA])