

## BIO-DATA

Name : M. VIJAYAN  
Date of Birth : 16th October 1941  
Institution : Molecular Biophysics Unit  
Indian Institute of Science  
Bangalore - 560 012.

### Academic and Professional Career

Degree	University	Year	Subject
M.Sc.	Allahabad University	1963	Physics
Ph.D.	Indian Institute of Science	1967	X-ray Crystallography

  

Position	Institution	Year
INSA Albert Einstein Professor	Indian Institute of Science Bangalore	2013-
DAE Homi Bhabha Professor	Indian Institute of Science Bangalore	2010-2013
Honorary Professor/ Distinguished Biotechnologist/Professor	Indian Institute of Science	2004-2010
Associate Director	Indian Institute of Science	2000-2004
Convener, Chairmen of Divisions	Indian Institute of Science	1996-2000
Chairman Division of Biological Sciences	Indian Institute of Science	1993-2000
Chairman Molecular Biophysics Unit	Indian Institute of Science	1985-1992
Professor	Indian Institute of Science	1984-2004
Associate Professor	Indian Institute of Science	1979-1984
Visiting Fellow	Oxford University, England	1976-1977
Assistant Professor	Indian Institute of Science	1974-1979
Institute Fellow	Indian Institute of Science	1971-1974
Post-doctoral Fellow	Oxford University, England	1968-1971

## **Publications and guidance of research**

Number of research publications	291
Guidance of Ph.D. Students	
Number awarded degree	36
Currently working	7
Post doctoral workers (Past)	26
Post doctoral workers (Present)	1

## **Fields of specialisation**

Biological Crystallography  
Molecular Biophysics

## **Honours and awards**

Fellow, Indian Academy of Sciences, 1983-  
Fellow, Indian National Science Academy, 1987-  
Fellow, National Academy of Sciences, India, 1990-  
Member, Guha Research Conference, 1980-1994  
Bhatnagar Prize for 1985 in Biological Sciences  
ASTRA Professor, Indian Institute of Science, 1991-94  
G.N. Ramachandran 60th Birthday Commemoration Medal of the Indian  
National Science Academy, 1994.  
Alumni award for Excellence in Research, Indian Institute of Science, 1996  
Federation of Indian Chamber of Commerce & Industry (FICCI)  
award in Life Sciences for 1995-96  
Ranbaxy Research Award in Basic Medical Sciences for 1996  
J L Nehru Birth Centenary Visiting Fellowship, Indian  
National Science Academy, 1999  
Om Prakash Bhasin Award, 2000  
K.S. Krishnan Memorial Lecture Award of the Indian National Science  
Academy, 2001  
Fellow, Third world Academy of Sciences, 2002-  
Jawaharlal Nehru Birth Centenary Award, Indian Science Congress  
Association, 2003-2004  
Padma Shri, 2004  
Distinguished Biotechnologist Award of the DBT, 2004  
The First CSIR/Science Congress G.N. Ramachandran Award for Excellence in  
Biological Sciences and Technology, 2004  
Goyal Prize in Life Sciences, 2005  
Distinguished Alumni Award, 2005, Indian Institute of Science  
Honorary Fellowship of the Indian Association for the Cultivation of Science,  
Kolkata, 2008-  
Lakshmipat Singhanian-IIM Lucknow National Leadership Award for Science and  
Technology, 2009  
Sir Devaprasad Sarvadhikari Medal for 2009, University of Calcutta  
D.P. Burma Memorial Lecture Award, 2010, Society of Biological Chemists (India)  
J. Das Endowment Lecture, NISER, Bhubaneswar, 2011

Champion of CSIR Award, 2012  
Professor Krishnaji Memorial Lecture Award of the National Academy of Sciences,  
India, 2012  
Kerala Science Award, 2012  
Honorary Fellow, Kerala Academy of Sciences, 2013  
SASTRA–G. N. Ramachandran Award, 2014

### **Roles in international organizations**

Chairman, Commission on Biological Macromolecules,  
International Union of Crystallography (IUCr), 1993-96  
Member, Commission on Biological Macromolecules,  
International Union of Crystallography (IUCr), 1987-96  
Member, Commission on Small Molecules,  
International Union of Crystallography (IUCr), 1984-90  
Member, Commission on Education and Development in  
Biophysics, International Union of Pure & Applied  
Biophysics (IUPAB), 1991-96  
Co-editor, Acta Crystallographica, 1993-2002  
Member, IUCr Subcommittee on the Union Calendar, 1996-2005  
Member, IUPAB Council, 1996-2002  
Member, IUPAB Task Force on Bioinformatics, 1996- 1998  
Member, Inter-Union Bioinformatics Group (ICSU), 1998-2002  
Member, Asia-Pacific International Molecular Biology Network, 1999-  
Vice-President, Asian Crystallographic Association, 2002-2004  
Co-editor, Crystallography Reviews, 2003-2014  
President, Asian Crystallographic Association, 2004-2007  
Member, Ad hoc group on Weighted Voting, ICSU, 2010  
Member, Council of Scientific Advisors, International Centre for Genetic  
Engineering and Biotechnology, 2009-2011

### **Roles in the Congresses of International Unions**

Organizing Chairman and speaker, Symposium on "Molecular Complexes and  
Inclusion Compounds", XIV th IUCr (Crystallography) Congress, Perth, Australia,  
August, 1987.

Invited speaker, Symposium on "The Problem of Protein Folding", 11th IUPAB  
(Biophysics) Congress, Budapest, Hungary, July, 1993.

Organizing Chairman, Symposium on "Molecular Structure and Biological  
Activity" XVI th IUCr (Crystallography) Congress, Beijing, China, August, 1993.

Invited speaker, Symposium on "Protein-Saccharide Interaction", XVI th IUCr  
(Crystallography) Congress, Beijing, China, August, 1993.

Organizing Chairman and speaker, Symposium on "Three-dimensional  
Structure of Proteins", XVIth IUBMB (Biochemistry and Molecular  
Biology) Congress, New Delhi, India, September, 1994.

Organizing Chairman, Symposium on "Protein-Carbohydrate Structure", XVII IUCr  
(Crystallography) Congress, Seattle, U.S.A., August, 1996

Invited speaker, Symposium on "Hot Structures", XVII IUCr (Crystallography) Congress, Seattle, U.S.A., August, 1996.

Chairman, Programme Committee, 13th IUPAB (Biophysics) Congress, New Delhi, India, September, 1999.

Member, Programme Committee, 19<sup>th</sup> IUCr (Crystallography) Congress, Geneva, August, 2002

Chaired a plenary lecture in the 19<sup>th</sup> IUCr (Crystallography) Congress, Geneva, August 2002

Chaired a plenary lecture in the 20<sup>th</sup> IUCr (crystallography) Congress, Florence, 2005

Invited speaker, Symposium on "Protein Structure and Allosteric Communication", 17<sup>th</sup> IUPAB (Biophysics) Congress, Beijing, October-November, 2011

### **Involvement in national bodies**

Member, National Committee for the International Union of Crystallography (IUCr), 1985-88

Chairman, National Committee for the International Union of Pure and Applied Biophysics (IUPAB), 1991-94

Member, Kerala State Committee on Science & Technology, 1981-1984

Member, Kerala State Committee on Science, Technology and Environment, 1991- 94, 1997-2003

Member, Research Advisory Committee, Central Leather Research Institute, Madras, 1984-87

Member, Research Council, Indian Institute of Chemical Biology, Calcutta, 1988-91  
Vice-President, Society of Biological Chemists, India, 1986-88

Member, Scientific Advisory Committee, National Institute of Immunology, New Delhi, 1992-

Member, Current Science Association, Bangalore, 1992-

Member, Council of the Indian Academy of Sciences, 1989-94, 2001- 2003

Coordinator, Curriculum Development Centre in Biophysics (UGC), 1986-1991.

President, Indian Biophysical Society, 1993-95

Member, Task Force on Bioinformatics, Department of Biotechnology, 1993-2002

Member, Research Council, Centre for Cellular and Molecular Biology, Hyderabad, 1994-1997

Member, Management Committee, CSIR Centre for Mathematical Modelling and Computer Simulation, Bangalore, 1994-1997

Member, Biochemistry, Biophysics, Molecular Biology, Microbiology, Immunology and Biotechnology Research Committee of the Council of Scientific and Industrial Research, 1989-92

Member, Physical Sciences Research Committee of the Council of Scientific and Industrial Research, 1995-98

Member, Kerala Education Commission, 1996-99

Senior Associate of the National Institute of Advanced Studies, 1996-

Member, Research Council, Central Drug Research Institute, Lucknow, 1998-2001, 2004-2007

Member, Council of the Indian Science Congress Association, 1998-99

President, Biology Section, National Academy of Sciences, India, 1998

Hon. Professor, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, 1998-

Member, Advisory Committee on Space Sciences (ADCOS), Indian Space Research Organization, 1998-2011

Member, Council of the National Academy of Sciences, India, 1999-2004

Member, Research Council, Central Food Technology Research Institute, 2001-2004

Founder President, Indian Crystallographic Association, 2001-2004

Member, Task Force on Infrastructure and Centres of Excellence, Department of Biotechnology, 2002-2005

Vice-President, National Academy of Sciences, India, 2002-2004

Member, Governing Body of National Institute of Immunology, New Delhi, 2001-2013

Member, Human Genetics and Genome Analysis Task Force, Department of Biotechnology, 2001-2005

Member, Research Area Panel-Scientific Advisory Committee, Centre for DNA Fingerprinting and Diagnostics, Hederabad, 2001-2005

Chairman, Research Council, Kerala State Committee for Science, Technology and Environment, 2003-2011

Chairman, Scientific Advisory Committee, National Institute of Immunology, New Delhi, 2003-

Chairman, Programme Advisory Committee on Biochemistry, Biophysics and Molecular Biology, Department of Science and Technology, 2004-2012

Member, Science and Engineering Research Council, Department of Science and Technology, 2004-2012

Member, Task Force on Infectious Disease Biology, Department of Biotechnology, 2005-2008

Vice-President, Indian National Science Academy, 2005-2007

Chairman, Task Force on Bioinformatics, Department of Biotechnology, 2006-2013

Chairman, Subject Expert Committee on Life Sciences, FIST Programme, Department of Science and Technology, 2006-

Member, Governing Body, Council of Scientific and Industrial Research, 2008-2013

President, Indian National Science Academy 2008-2010

Chairman, Research Council, Indian Institute of Chemical Biology, 2010-

### **Summary of scientific contributions**

Professor M. Vijayan has made original and novel contributions pertaining to the structure and carbohydrate binding properties of lectins; the role of hydration in the mobility and action of proteins; structural biology of mycobacterial proteins; and molecular recognition and aggregation of amino acids and peptides, and their probable evolutionary implications.

Prof. Vijayan and his colleagues have dealt with four of the five structural classes of plant lectins. They have studied in detail lectins from peanut, winged bean (basic and acidic), jackfruit (jacalin and artocarpin), garlic, banana and snake gourd. They demonstrated the need for considering "open" quaternary structures when dealing with multimeric proteins and the variability in the quaternary association of legume lectins and lectins with  $\beta$ -prism I fold. They established  $\beta$ -

prism I fold as a lectin fold. They elucidated the roles of water-bridges, post-translational modification, oligomerisation and variation in loop length as strategies for generating ligand specificity. Their studies provided valuable insights into the structural basis of carbohydrate specificity and the biological implications of this specificity. Currently, they are involved in extending the work to lectins from mycobacteria.

Using an approach involving water-mediated transformations Professor Vijayan's group has elucidated the nature of the flexibility in lysozyme and ribonuclease A and identified the invariant features in their hydration shells. They have also demonstrated the presence of ensembles of relaxed and tense states of hemoglobin and water-mediated loop movement in  $\beta$ -lactoglobulin. More interestingly, these studies have provided insights into the relationship among hydration, molecular mobility and protein action.

Prof. Vijayan orchestrated a national programme on the structural biology of microbial pathogens. His own personal research in the area has been concerned with mycobacterial, particularly TB, proteins. The specific systems studied by him include RecA, single stranded DNA binding protein, ribosome recycling factor, pantothenate kinase, peptidyl tRNA hydrolase, uracil DNA glycosylase and DNA binding protein in stationary phase cells. He has elucidated the specific structural features of these proteins in mycobacteria, which, among other things, have opened up avenues for structure-based inhibitor design, with the eventual objective of drug development.

Furthermore, Professor Vijayan and his colleagues have elucidated, using a novel approach based on molecular complexes, molecular recognition and aggregation patterns involving amino acids and peptides, which have been shown to have implications to chemical evolution and origins of life. Their other contributions pertain to the structure and interactions of non-steroidal anti-inflammatory analgesics, ionophores and related compounds, side chain conformation in proteins, and additional binding sites in lysozyme.

In addition, Professor Vijayan has played a leading role in the development of structural biology in India and actively participated in international efforts in the area.

### **Scientific biographical sketch and impact of contributions**

Professor M. Vijayan, a physicist by training, had his early education at Trichur (Kerala) and Allahabad, and obtained his Ph.D. degree in X-ray crystallography from the Indian Institute of Science, Bangalore, in 1967. His post doctoral stint in Professor Dorothy Hodgkin's research group at Oxford, where he worked on the structure of insulin, during 1968-71 facilitated the transition of his interests to biological problems. Since his return to India in 1971, he has all along been at the Indian Institute of Science except for a year-long visit to Oxford in 1976-77 as a Senior Visiting Fellow, again to work with Professor Dorothy Hodgkin.

The resources available to him when he returned to India in 1971, did not permit the immediate initiation of macromolecular crystallography. It was then important to pursue a research programme which is scientifically interesting

while at the same time could be carried out using limited resources and technology. It is in this context that he initiated a programme involving the preparation and X-ray analysis of crystalline complexes of amino acids and peptides, with the original objective of elucidating, at the atomic resolution, the interactions important in the structure, assembly and function of proteins. Subsequently, the results of this programme were found to have implications to chemical evolution and origin of life. Since then a substantial amount of work has been carried out with the ultimate aim of elucidating the probable role of molecular interactions and aggregation in prebiotic polymerisation, chiral discrimination and emergence of the primitive multi-molecular systems through self-assembly. These investigations, still being pursued, have also been of general interest in relation to molecular recognition, predictable aggregation patterns and inclusion phenomena. He used the approach involving crystalline complexes to study the structure and interactions of non-steroidal anti-inflammatory analgesics as well. His other contributions in the area of small molecule crystallography include structural studies on ionophores and related compounds.

Since the early eighties, one of his major concerns has been the development of biological macromolecular crystallography in India. The mandate of Professor Vijayan's laboratory was not only to set up a vibrant research group at Bangalore, but also to function as a national nucleus for the development of the area. This mandate has been pursued seriously. At present, there are several dozen active research groups in the area in the country, to a substantial extent led and manned by Professor Vijayan's former students and their students. The Bangalore group led by him has in the meantime grown into a major internationally recognised centre for frontline research in macromolecular crystallography.

An important protein crystallography programme pursued by him is concerned with lectins, which specifically bind to cell surface carbohydrates and have applications that flow from this specificity. The *de novo* structure determination of the tetrameric peanut lectin, which is specific to the tumour-associated T-antigenic disaccharide, has been a major land mark in the development of structural biology in the country and has received considerable international attention on account of the unusual 'open' quaternary association in the molecule, which violates the accepted principles of quaternary association. This structure and those of basic and acidic winged bean lectins, analysed later by Professor Vijayan's group, demonstrate that legume lectins constitute a family of proteins in which small alterations in essentially the same tertiary structure leads to large variations in quaternary association, an observation relevant to protein folding. Through the X-ray analysis of several carbohydrate complexes of peanut lectin, they have demonstrated the importance of water in carbohydrate binding, including the generation of specificity. The *de novo* structure determination of jacalin, one of the two lectins found in jackfruit seeds and again specific to T-antigen, in his laboratory has resulted in the identification of a novel three-fold symmetric lectin fold made up of three four-stranded  $\beta$ -sheets. This structure, exhibits a novel carbohydrate binding site in which specificity is generated by a post translational modification, the first known instance of this kind. Professor Vijayan's group has also demonstrated that artocarpin, the second lectin from jackfruit seeds, is homologous to jacalin, despite the two having different physico-chemical properties and carbohydrate specificities. The binding sites of both the lectins have

been thoroughly characterized. The study also brought out variation in loop length as a strategy for generating oligosaccharides specificity. That from garlic is yet another lectin that has been studied by the group. A comparison of the structure of this dimeric lectin with that of the tetrameric snow drop lectin demonstrates how carbohydrate specificity could be generated through oligomerisation. The other lectins studied by Prof. Vijayan's group are those from snake gourd and banana. The work on banana lectin led to a thorough characterisation of the variability in the quaternary structure of lectins with the  $\beta$ -Prism I fold. His studies have led to valuable insights into, and detailed information on, the structural basis for the carbohydrate specificity of lectins, and its biological significance. Furthermore, his investigations on the structure and sequences of relevant lectins have illuminated the evolutionary history of  $\beta$ -prism fold lectins through gene duplication and fusion, with particular reference to the number sugar binding sites. Professor Vijayan has now initiated structural studies on lectins from mycobacteria. The results of these studies are expected to be important in relation to host-pathogen interactions.

In another protein crystallographic project, Professor Vijayan has investigated the variability in protein hydration and its structural consequences using an approach involving water-mediated transformations. Using this approach, he elucidated the nature of the flexibility in lysozyme and ribonuclease A molecules and identified the invariant features in their hydration shell. More interestingly, the studies have also provided valuable insights into the relationship among hydration, molecular flexibility and enzyme action. More recently, the existence of ensembles of relaxed and tense states in hemoglobin, has been demonstrated. The work on hemoglobin and also that on  $\beta$ -lactoglobulin further demonstrate that the structural changes associated with partial dehydration are similar to those that occur during protein action.

In yet another project, Professor Vijayan's group has characterized two additional binding sites in lysozyme, which are presumably important for the attachment of the enzyme to the bacterial cell wall.

Recently, Professor Vijayan has orchestrated a national programme on the structural biology of microbial pathogens, a programme very relevant to national needs. His own personal research in the area has been concerned with TB and other mycobacterial proteins. A substantial part of the work of his group has been on proteins involved in recombination and repair. They determined the structures of Rec A from *Mycobacterium tuberculosis* and *M. smegmatis* and several of their complexes. The structures illuminated the trajectory of allosteric transitions in this important enzyme. Their work on RuvA elucidated the role of oligomerisation in the action of the protein. They determined the structure *M. tuberculosis* single stranded DNA binding protein, which has a quaternary structure different from the protein from other sources. The same is true of the protein from *M. smegmatis*. Yet another protein involved in DNA repair analysed by them is uracil N-glycosylase from *M. tuberculosis*. They analysed the structures of two *M. Smegmatis* DNA-binding proteins in stationary phase cells. The structures led to valuable insights into the assembly of the multimeric protein and the mode of DNA-binding by it. Proteins involved in protein synthesis analysed by them are *M. tuberculosis* ribosome recycling factor peptidyl t-RNA hydrolase. The analyses provided new insights into the mobility of the protein molecules and its biological implications. Professor Vijayan's group is also examining enzymes in the CoA synthesis pathway. They



have also initiated efforts at inhibitor design with the eventual aim of contributing to drug development.

In addition to carrying out his own research, Professor Vijayan has played a leadership role at Bangalore and in India as a whole. He led the Molecular Biophysics Unit at the Indian Institute of Science, Bangalore, a leading centre of structural biology, for more than seven years (1985-92) as its Chairman. Then he was the Chairman of the Biology Division at the Institute from 1993 to 2000, a Division which encompasses five departments, and three facilities with about 60 faculty members and more than 250 graduate students and post doctoral fellows on its rolls. Then he worked for more than four years as the Associate Director of the Institute. His pioneering role in the development of macromolecular crystallography in the country has already been mentioned. If India has become internationally competitive in this area today, it is to a substantial extent due to Professor Vijayan's efforts. He also played a significant role in organising Indian biophysicists into a coherent scientific community during his chairmanship of the Indian National Committee of IUPAB and Presidentship of the Indian Biophysical Society. He is the founder President of the Indian Crystallographic Association. His contributions have been well recognised in the country as evidenced by the several Academy fellowships and awards he has received. He has also been President of the Indian National Science Academy.

Professor Vijayan's efforts have received considerable international attention. For example, he was invited to organise and chair symposia at the IUCr Congresses thrice (1987 at Perth, 1993 at Beijing and 1996 at Seattle). He organized and chaired a symposium at the 1994 Delhi Congress of IUBMB as well. He was an invited speaker at the Biophysics Congresses at Budapest in 1993 and at Beijing in 2011 and the IUCr Congresses at Beijing in 1993 and at Seattle in 1996. He served on the Programme Committee of the Geneva IUCr Congress in 2002 and chaired a plenary lecture in it. He chaired a plenary lecture at the Florence IUCr Congress in 2005 as well. He has served on the IUCr Commission on Small Molecules, the IUPAB Commission on Education and Development in Biophysics, the IUPAB Task Force on Bioinformatics and the Calendar Committee of IUCr. He has been the Chairman of the IUCr Commission on Biological Macromolecules, an important Commission which oversees the IUCr activities in the area of macromolecules. He was the first Co-editor of the prestigious IUCr journal *Acta Crystallographica* from the third world. He was elected to the Council of IUPAB at the 1996 Biophysics Congress at Amsterdam and re-elected at the 1999 New Delhi Congress. He has also been a member of the Inter-Union Bioinformatics Group of ICSU. He served as the president of the Asian Crystallographic Association during 2004-2007.

1. M. Vijayan and M.A. Viswamitra (1965) Morphology and space group of hexaantipyrene perchlorate complexes of  $\text{Ca}^{++}$  and  $\text{Zn}^{++}$  and pentaantipyrene perchlorate of  $\text{Cu}^{++}$ . *Zeit.Krist* **122**, 153-155.
2. M. Vijayan and M.A. Viswamitra (1965) The Crystal structure of magnesium hexaantipyrene perchlorate. *Indian J. Pure and Applied Physics* **3**, 357-358.
3. M. Vijayan and M.A. Viswamitra (1966) The crystal and molecular structure of lead hexaantipyrene perchlorate. *Acta Cryst.* **21**, 522-530.
4. M. Vijayan and M.A. Viswamitra (1967) The crystal and molecular structure of magnesium hexaantipyrene perchlorate. *Acta Cryst.* **23**, 1000-1009.
5. M. Vijayan and M.A. Viswamitra (1968) A refinement of the structure of calcium hexaantipyrene perchlorate and a comparative study of some metal hexaantipyrene perchlorates. *Acta Cryst.* **B24**, 1067-1076.
6. M. Vijayan (1968) Metallic and molecular compounds of antipyrene. *J. Scientific and Industrial Research* **27**, 98-102.
7. M. Vijayan (1966) Unit cell and space group of monoglycine nitrate. *Indian J. Pure and Applied Physics* **4**, 251.
8. M. Vijayan and K. Jayalakshmi (1967) Space group and unit cell of diglycine strontium chloride trihydrate and diglycine calcium chloride tetrahydrate. *Acta Cryst.* **23**, 669.
9. M. Vijayan (1967) Crystallographic data on sodium trihydrogen selenite. *Current Science* **36**, 230.
10. M. Vijayan (1968) The crystal structure of sodium trihydrogen selenite. *Acta Cryst.* **B24**, 1237-1241.
11. V. Kalyani and M. Vijayan (1967) Preliminary crystallographic investigations on the racemic isomers of some diarylbipthalidyls. *Current Science* **36**, 662-663.
12. V. Kalyani and M. Vijayan (1969) A refinement of the structure of meso-3,3'-di-(p-chlorophenyl)-bi-3-phthalidyl. *Acta Cryst.* **B25**, 252.-260.
13. V. Kalyani and M. Vijayan (1969) The crystal and molecular structure of 3-(p-bromophenyl) phthalide. *Acta Cryst.* **B25**, 1281-1288.
14. T.L. Blundell, E. Dodson, G. Dodson and M. Vijayan (1969) The low resolution crystal structure of rhombohedral zinc insulin. *Acta Cryst.* **A25**, S 184.
15. M.J. Adams, T.L. Blundell, E.J. Dodson, G.G. Dodson, M. Vijayan, E.N. Baker, M.M. Harding, D.C. Hodgkin, B. Rimmer and S. Sheat (1969) Structure of rhombohedral 2 zinc insulin crystals. *Nature* **224**, 491-495.
16. T.L. Blundell, G.G. Dodson, E. Dodson, D.C. Hodgkin and M. Vijayan (1971) X-ray analysis of the structure of insulin. *Recent Progress in Hormone Research* **27**, 1-40.
17. T.L. Blundell, E. Dodson, G. Dodson and M. Vijayan (1971) The structure of a protein hormone, insulin. *Contemp. Phys.* **12**, 209-228.

18. T.L. Blundell, J.F. Cutfield, E.J. Dodson, G.G. Dodson, D.C. Hodgkin, D.A. Mercola and M. Vijayan (1971) Atomic positions in rhombohedral 2 zinc insulin crystals. *Nature* **231**, 506-511.
19. T.L. Blundell, J.F. Cutfield, S.M. Cutfield, E.J. Dodson, G.G. Dodson, D.C. Hodgkin, D. Mercola and M. Vijayan (1972) Structure and biology of insulin. *Acta Cryst.* **A28**, S 34.
20. M. Vijayan (1971) An X-ray crystallographic study of antipyrine, amidopyrine, phenylbutazone and salipyrine. *Current Science* **40**, 262-264.
21. M. Vijayan (1971) Crystal structure of antipyrine. *Current Science* **40**, 489-490.
22. E. Dodson and M. Vijayan (1971) The determination and refinement of heavy atom parameters in protein heavy atom derivatives. Some model calculations using acentric reflections. *Acta Cryst.* **B27**, 2402-2411.
23. T.P. Singh and M. Vijayan (1972) An X-ray examination of the crystalline complex between amidopyrine and barbital. *Current Science* **41**, 700-701.
24. D.C. Hodgkin, T.L. Blundell, J.F. Cutfield, S.M. Cutfield, G. Dodson, E.J. Dodson, D.M. Mercola and M. Vijayan (1972) The arrangement in three dimensions of the atoms in insulin molecules and crystals. In 'Insulin Action' edited by I.B. Fritz, Academic Press, New York and London p.1-28.
25. T.P. Singh and M. Vijayan (1973) Structural studies of analgesics and their interactions. I.: The crystal and molecular structure of antipyrine. *Acta Cryst.* **B29**, 714-720.
26. T.P. Singh, T.N. Bhat and M. Vijayan (1973) Crystallization and crystal data of acetoaminophen and metamizol. *Current Science* **42**, 384.
27. M. Vijayan (1973) Determination of heavy atom positions in protein crystallography. An improved difference Fourier synthesis incorporating anomalous scattering data. *Current Science* **42**, 531-532.
28. T.P. Singh and M. Vijayan (1974) Structural studies of analgesics and their interactions. II. The crystal structure of a 1:1 complex between antipyrine and salicylic acid (salipyrine). *Acta Cryst.* **B30**, 557-562.
29. T.N. Bhat and M. Vijayan (1974) Crystal Structure of lysine aspartate. *Current Science* **43**, 276-277.
30. T. Ramasarma and M. Vijayan (1974) Suprahelical arrangements of hydrogen bonds in peptide helices. *FEBS Letters* **41**, 307-309.
31. T.N. Bhat, T.P. Singh and M. Vijayan (1974) Isonicotinic acid hydrazide - A reinvestigation. *Acta Cryst.* **B30**, 2921-2922.
32. T.P. Singh and M. Vijayan (1975) Crystal structures of amidopyrine and phenylbutazone. *Current Science* **44**, 153-154.
33. T.P. Singh and M. Vijayan (1975) The structure and interaction of drugs which inhibit prostaglandin biosynthesis. Crystal and molecular structure of phenylbutazone. *Acta Cryst.* **A31**, S 51-52.

34. T.N. Bhat and M. Vijayan (1975) Structural studies on crystalline complexes between amino acids. Crystal structure of arginine glutamate monohydrate. *Acta Cryst.* **A31**, S 48.
35. T.P. Singh and M. Vijayan (1975) The crystal structure of a 2:1 complex between phenylbutazone and piperazine. *Current Science* **44**, 698-699.
36. M. Vijayan (1975) Macromolecular Crystallography. *J. Indian Institute of Science* **57**, 377-398.
37. T.N. Bhat and M. Vijayan (1976) X-ray studies on crystalline complexes involving amino acids. I. Crystal structure of L-Lysine L-aspartate. *Acta Cryst.* **B32**, 891-895.
38. T.P. Singh and M. Vijayan (1976) Structural studies of analgesics and their interactions III. The crystal and molecular structure of amidopyrine. *Acta Cryst.* **B32**, 2432-2437.
39. M. Vijayan (1976) Dimensions of the amino acid group, amino acid side chains and the peptide linkage. In 'Hand Book of Biochemistry and Molecular Biology' Proteins- Vol. II. Edited by G.D. Fasman, CRC Press Cleveland, Ohio. p. 742-758.
40. T.P. Singh and M. Vijayan (1977) Structural studies of analgesics and their interactions. IV. Crystal structures of phenylbutazone and a 2:1 complex between phenylbutazone and piperazine. *J. Chem. Soc. Perkin II*, 693-699.
41. V. Sudhakar and M. Vijayan (1977) Preparation and preliminary X-ray studies of arginine ascorbate, a crystalline complex between an amino acid and a Vitamin. *Current Science* **46**, 9.
42. H.M. Krishnamurthy, M. Vijayan and L. Brehm (1977) Crystal structure of metamizol. *Current Science* **46**, 221-222.
43. T.N. Bhat and M. Vijayan (1977) X-ray studies of crystalline complexes involving aminoacids. II. The crystal structure of L-arginine L-glutamate. *Acta Cryst.* **B33**, 1754-1759.
44. T.N. Bhat and M. Vijayan (1978) X-ray studies of crystalline complexes involving amino acids. III. The structure of the twinned pseudo symmetric crystals of a complex between histidine and aspartic acid. *Acta Cryst.* **B34**, 2556-2565.
45. A.K. Chandra, B.S. Sudhindra, M. Vijayan and T. Ramasarma (1978) A theory on the migration of an extraneous electron across hydrogen bonds in polypeptides. *J. Theoretical Biology* **74**, 1-9.
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