ANIL AGGRAWAL'S
Internet Journal of Forensic Medicine and Toxicology
The world's first online journal devoted entirely to forensic medicine and toxicology · Published 1 January and 1 July

VOL. 5, NO. 1
Downloaded from www.anilaggrawal.com · ISSN 0972-8074 (Online) · https://www.anilaggrawal.com/ij/vol_005_no_001/reviews/tb/page003.html

Book Reviews: Technical Books Section

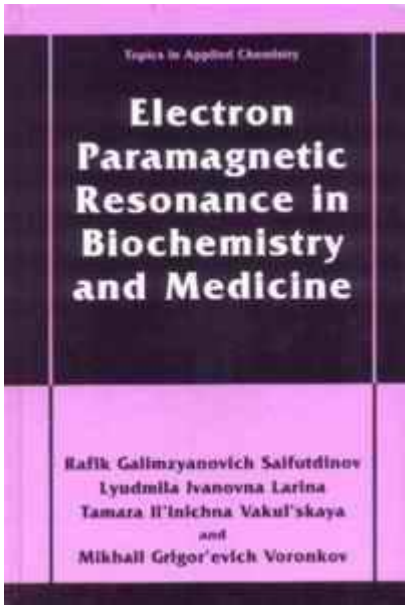
CITE THIS ARTICLE
Thomas S.S. Electron Paramagnetic Resonance in Biochemistry and Medicine (Book Review). *Anil Aggrawal's Internet Journal of Forensic Medicine and Toxicology, 2004*; Vol. 5, No. 1 (January - June 2004): ; Published June 8, 2004,

Email Dr. Thomas by clicking here

An excellent book on the application of Electron Paramagnetic Resonance

Electron Paramagnetic Resonance in Biochemistry and Medicine, by Rafik Galimzyanovich Saifutdinov, Lyudmila Ivanovna Larina, Tamara Il'inichna Vakul'skaya and Mikhail Grigor'evich Voronkov. Hard Bound, 6.5" x 10.0" (A title in "Topics in Applied Chemistry" series - Series editors Alan R. Katritzky and Gebran J. Sabongi)
Kluwer Academic/Plenum Publishers, 233 Spring street, New York, New York 10013. Publication Date 2001, xiv+268 pp., ISBN 0-306-46531-0. Price EUR 94.00 / USD 103.00 / GBP 65.00

Click cover to buy from Amazon

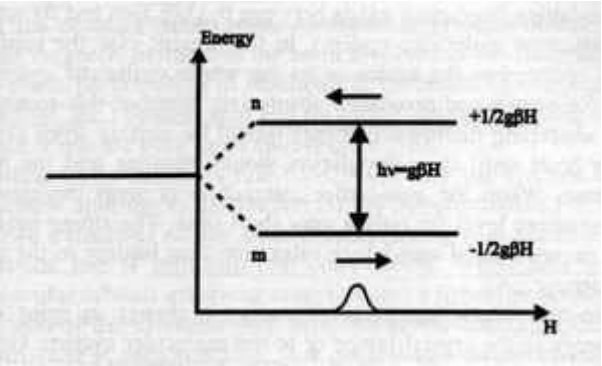


Scientific and technical progress contributes a great deal to the development of medical science. This book demonstrates the unlimited possibilities of the application of Electron Paramagnetic (Spin) Resonance (EPR).

The EPR method was discovered in 1944 by Eugene Konstantinovich Zavoisky in Kazan. EPR spectroscopy is an objective and accurate method of recording paramagnetic centers (PMC) widely accepted in chemistry, biochemistry, biology and medicine. PMC serve as indicators of alterations in redox processes owing to the presence of free radicals and cations of transition microelements in many biological tissues and fluids. In the middle fifties, EPR spectroscopy was first used for the investigation of tissues and fluids in human and animals in the United States and the Soviet Union. The first use of EPR spectroscopy in biochemistry and medicine was aimed at studying malignant tumors.

This book attempts to fill in the gap in literature data devoted to practical aspects of EPR spectroscopy in medicine and biochemistry. The quantitative and qualitative composition of PMC in normal individuals and patients suffering from different diseases is presented. Special attention is given to EPR examination of bio-molecules playing an essential role in the vital activities of man and the possible use of this method for the investigation of drugs, toxicants, metabolites, food products, dosimetry and diagnosis of irradiation injury, archaeology, etc. Fundamental problems related to the study of mechanisms of the development of oncologic, cardiovascular and other diseases including AIDS have been elucidated.

The main condition of electron paramagnetic resonance origin (under influence of the external magnetic field the energy levels of UEs are split). This figure appears on page 3 of the book.



This book will be useful to doctors of specialties like medicine, surgery, otorhinolaryngology, etc, biologists, biochemists, biophysicists and chemists engaged in ESR spectroscopy. It can also be useful for students at the senior undergraduate or graduate level. The book is divided into four chapters:

1. Electron Paramagnetic Resonance (EPR): Theory and Method

2. Paramagnetic centers in the Human Biological Media

3. Paramagnetic centers in the organisms of volunteers in various pathological states

4. Other aspects of EPR investigation of biological specimens

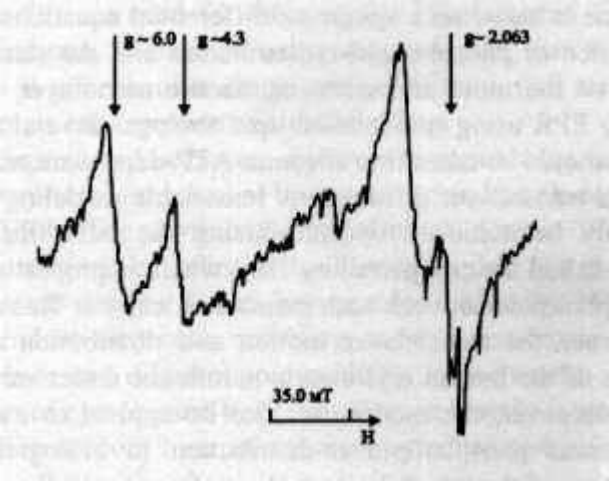
1. EPR: Theory and Method

It is divided into 2 sections

(i) 1st section deals with the fundamentals of the EPR theory

(ii) 2nd section deals with procedures for studying paramagnetic centers.

The EPR spectrum of human erythrocyte free radicals. The registration conditions: temperatures -77^0 K, SHF power -5 mW, magnetic field scanning velocity -50 mT/min, HF modulation -0.5 mT, time constant -0.3 sec. This figure appears on page 24 of the book.



EPR is based on the possibilities of recording free unpaired electrons (UEs) in atomic, crystalline ionic and molecular structures; in compounds of transition metals (copper, vanadium, chromium, molybdenum, manganese, iron, nickel, etc), upon cleavage of covalent chemical bonds. The UEs are found in PMC of molecules and atoms. The difference in energy between the UEs on a lower energy level and on the upper level in an external magnetic field is responsible for the EPR signal intensity.

Details of preparation of different samples like blood, synovial fluid, saliva, nasal secretion, duodenal aspirate and feces along with their storage are given. The number of PMC in biological fluids is determined using a method of EPR signal area double integration by calibration curves.

2. Paramagnetic centers in the human biological media:

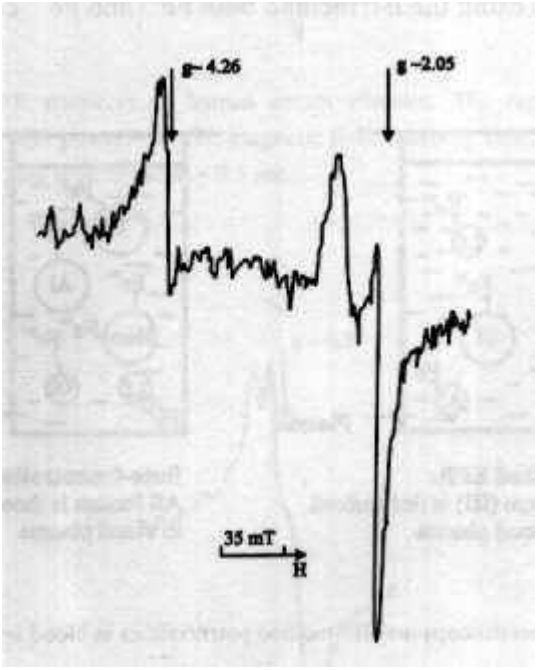
i) Erythrocytes

EPR was used for the assessment of transverse distribution and mobility of labeled phospholipid analogs in biological erythrocyte membranes by selective chemical destruction of the fluorescent label in the outer monolayer with dithionite. It has been used to study irradiation induced erythrocyte hemolysis; investigation of erythrocyte permeability for cryoprotectors influence of calcium in human erythrocyte cytosol on the transmembrane movements of spin labeled phospholipids.

ii) Blood Plasma

Determination of Fe^{3+} and Cu^{2+} concentration in plasma; mutation in their binding proteins (e.g. transferring) and plasma lipids.

The EPR Spectrum of human serum blood. The registration conditions: temperatures -77^0 K, SHF power -5 mW, magnetic field scanning velocity -50 mT/min, HF modulation -0.5 mT, time constant -0.3 sec. This figure appears on page 35 of the book.



iii) Saliva

Mn^{2+} and Fe^{3+} EPR signals were recorded

iv) Nasal secretion

Mn^{2+} signal was present

v) Teeth

CO_3^{3-} and CO_2^{-} signals are seen in the tooth enamel

vi) Stomach contents

PMC - Mn^{2+} , Hem-NO

vii) Duodenal contents

PMC - Mn^{2+}, Cu^{2+}, Fe^{3+}

viii) Synovial fluid

PMC - Fe^{3+} and Cu^{2+}

ix) Feces

PMC - Fe^{3+}, Cu^{2+}, Mn^{2+} Hem-NO, and free radicals

...EPR spectroscopy was used for measurements of the surface potential and apoprotein structure of low density lipoproteides (LDL) and high density lipoproteides (HDL). It was also used to evaluate the effect of lipid peroxidation (LPO) on the structure of surface proteolipid layer of human serum LDL which results in cholesterol accumulation. Free radical (FR) caused injury to the endothelium has also been studied. In patients with progressive stenocardia the erythrocyte MetHb level and blood plasma free radical content increase with the severity of state, whereas in patients with hypertensive disease the blood lipid a-tfq concentration decreases...

3. Paramagnetic centers in the organism of volunteers and patients in various pathological states

i) Biological Substrates of normal individuals

PMC give an exact and fine picture of the state of metabolic and general functional activities of tissues and the organism as a whole for e.g. male blood donors have higher concentration of Fe^{3+} and lower Cu^{2+} -ceruloplasmin than in women.

Dehydration causes a loss of paramagnetism leading to reduction of Fe^{2+}. In regular donors the free radical level is higher compared to new donors. The Mn^{2+} concentration in the saliva of women donors is lower than in male saliva. In feces of women the Fe^{3+} signal is higher than that in men.

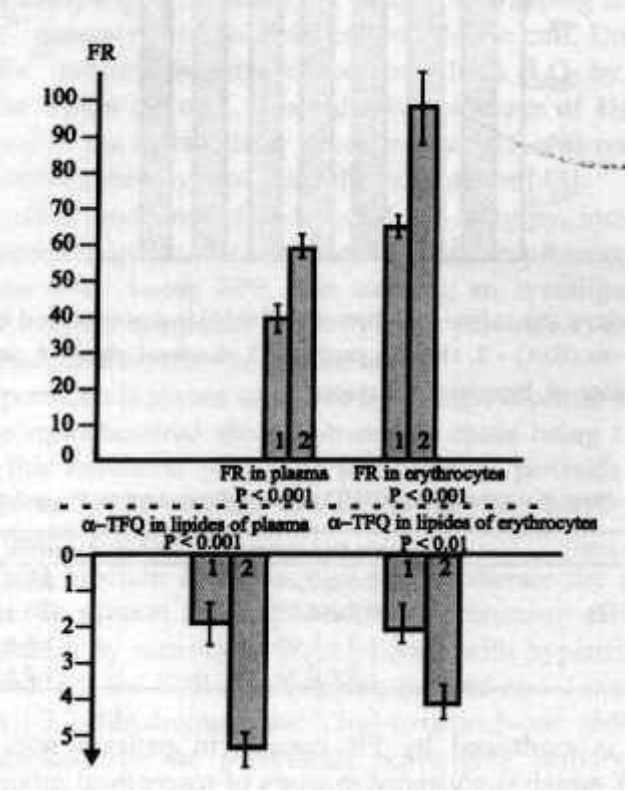
ii) Ischaemic heart Disease

EPR spectroscopy was used for measurements of the surface potential and apoprotein structure of low density lipoproteides (LDL) and high density lipoproteides (HDL). It was also used to evaluate the effect of lipid peroxidation (LPO) on the structure of surface proteolipid layer of human serum LDL which results in cholesterol accumulation. Free radical (FR) caused injury to the endothelium has also been studied. In patients with progressive stenocardia the erythrocyte MetHb level and blood plasma free radical content increase with the severity of state, whereas in patients with hypertensive disease the blood lipid a-tfq concentration decreases. In ischemic patients and in reperfusion injury the content of erythrocyte and plasma free radicals are higher than in patients with other diseases and in normal individuals, being higher the heavier the patient's state. EPR method was used for assessment of functional viability of a heart conserved with a goal of using as a transplant.

iii) Hypertensive Disease

Plasma and erythrocyte FR concentration is considerably higher than in healthy individuals.

Blood free radical concentration (10^{-6} M) in donors with microfocal (1) and macrofocal (2) myocardial infarction. This figure appears on page 86 of the book.



iv) Blood Diseases

With increasing disease (e.g. iron-deficient anemia) severity the MetHb content increases and that of Cu^{2+} and Fe^{3+} lowers. The erythrocyte FR concentration is increased and the saliva Mn^{2+} content increases and later decreases as the disease develops. EPR spectroscopy provides a tool for the operative diagnosis of iron-deficiency states in human beings.

v) Hemostasis disorder

The EPR method was employed to study phospholipid distribution in thrombocyte plasma membranes in the process of aging. The EPR data emphasize the importance of maintaining the plasma membrane asymmetry to increase the hemostatic effectiveness of transfused thrombocyte concentrates.

vi) Diseases of the gastrointestinal tract

In events of peptic ulcer, especially, duodenal ulcer the erythrocyte FR concentration is slightly increased. Plasma Fe^{3+} is decreased whereas that of Cu^{2+} is increased and an Hem-NO signal was observed in chronic gastritis and ulcer.

A highly sensitive method to determine HbsAg is based on assessment of the peroxidase activity using EPR measurements of the stability of nitroxide radicals. The presence of Fe^{3+} and FR in plasma, FR in erythrocytes, and FR, Cu^{2+} and Mn^{2+} in portion B of the duodenal contents is the most informative diagnostic criterion of cholecystitis exacerbation.

…A combination of EPR with MR imaging of kidneys was proved to be very useful for monitoring renal oxygen tension and changes in oxygen distribution. EPR method revealed a correlation between FR level and erythrocyte hemolysis in acute renal failure. The serum SOD activity was significantly higher in patients with chronic renal failure (CRF) and chronic glomerulonephritis

than in healthy adults. In the terminal stage of CRF the plasma Cu2+-ceruloplasmin EPR signal intensity is decreased...

vii) Lung diseases

Using EPR spectroscopy it was found that ceruloplasmin/transferrin (CP/TF) ratios and erythrocyte superoxide dismutase (SOD) level, indicate an activated antioxidant system in the patients of non-specific chronic lung diseases. EPR spectroscopy allowed elucidation of the role of hydroxy radicals in coal pneumoconiosis pathogenesis.

PMC concentration is dependent on both the form of chronic lung disease and severity of inflammatory process (e.g. bronchial asthma). Oxygen radicals with a unpaired electron plays an important role in the pathogenesis of many lung diseases especially in obstructive lung diseases. In chronic diseases of upper respiratory tracts the nasal secretion Fe^{3+} content is noticeably reduced.

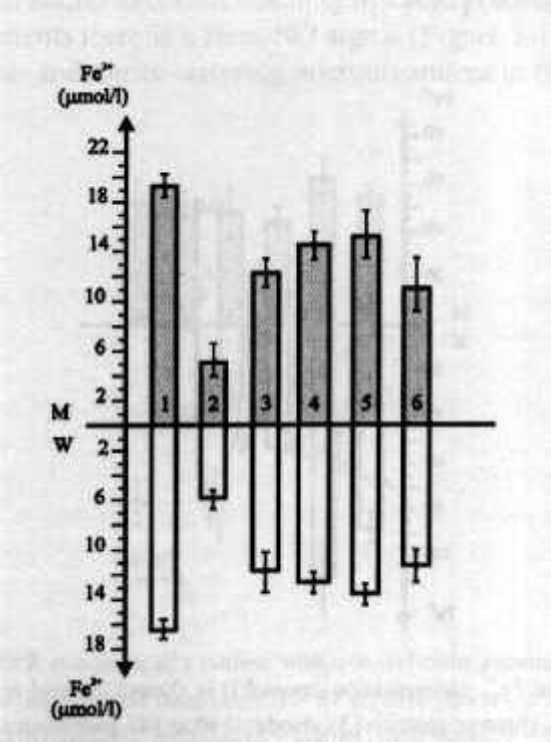
viii) Diseases of kidneys

A combination of EPR with MR imaging of kidneys was proved to be very useful for monitoring renal oxygen tension and changes in oxygen distribution. EPR method revealed a correlation between FR level and erythrocyte hemolysis in acute renal failure. The serum SOD activity was significantly higher in patients with chronic renal failure (CRF) and chronic glomerulonephritis than in healthy adults. In the terminal stage of CRF the plasma Cu^{2+}-ceruloplasmin EPR signal intensity is decreased.

ix) Diabetes

Non-enzymatic glycation of reactive amino groups in model proteins increases the rate of FR production at physiologic pH by nearly fifty-fold over non-glycated protein. Dimethylsulfoxide/ ascorbyl free radical (DMSO/AFR) complex has been proposed.

Plasma ion Fe^{3+} concentration (mcmol/l) in donors (1) and in patients with iron deficiency anaemia (2), chronic gastritis (3), duodenal ulcer (4), gastric ulcer (5), ischemic heart disease (6). M - man, W - women. This figure appears on page 111 of the book.



x) Nervous System Diseases

Diminished concentrations of Cu^{2+} and Fe^{3+} ions and increased free radicals are observed in Alzheimer's disease. Amyloid formation has been successfully monitored by EPR spectroscopy. NO. level is increased in Parkinson's disease brain.

xi) Diseases of Joints and Connective tissue

A considerable decrease in plasma Fe^{3+} concentration in patients with rheumatoid arthritis may serve as a differential criterion of this disease. The Cu^{2+}-ceruloplasmin and Fe^{3+} transferrin levels in blood plasma of RA patients is increased too.

xii) Myoglobin Pathology

The role of proximal and distal histidine residue on the interaction between the bound ligand and the myoglobin molecule have been studied by EPR spectroscopy.

xiii) Cutaneous Diseases

Oxygen free radicals have been found to play a role in keloid. EPR method using nitroxide radicals has a wide application in dermatologic research for studying biophysical properties of skin lipids, epidermal membranes and noninvasive and direct in vivo monitoring of drugs-induced radical formation in the skin.

...EPR spectroscopy is useful in the measurement of FR levels in order to assess the drug-sensitivity of larynx tumor. Nasal secretion FR levels are high in patients with vasomotor rhinitis and it is low in nasal and accessory nasal sinus pathologies. In cases of sub-and atrophic alteration in the nasal cavity the Cu 2+ content in the nasal mucous membrane is increased. The changes in Fe 3+ and Cu 2+ concentration and consequently in Cu 2+ /Fe 3+ ratio which is a factor of nasal secretion antioxidant properties, are related to the rhino-haematobarrier functional state and to the dynamics of metalloproteid supply from blood flow...

xvi) Gynecologic Diseases

A decrease in iron level in pregnant women has been found by EPR spectroscopy.

xv) Oncologic Diseases

Oncologic patients were found to have decreased plasma Fe^{3+} - transferrin and increased Cu^{2+}-ceruloplasmin concentrations.

xvi) Ophthalmic Diseases

EPR spectroscopy has found much use for the lens studies. SOD activity and glutathione (GSH) concentrations significantly decrease in human lenses with senile cataracts as the cataract advances. Peroxidative reactions occur in cataractous lenses.

xvii) Otorhinolaryngologic Diseases

EPR spectroscopy is useful in the measurement of FR levels in order to assess the drug-sensitivity of larynx tumor. Nasal secretion FR levels are high in patients with vasomotor rhinitis and it is low in nasal and accessory nasal sinus pathologies. In cases of sub-and atrophic alteration in the nasal cavity the Cu^{2+} content in the nasal mucous membrane is increased. The changes in Fe^{3+} and Cu^{2+} concentration and consequently in Cu^{2+}/Fe^{3+} ratio which is a factor of nasal secretion antioxidant properties, are related to the rhino-haematobarrier functional state and to the dynamics of metalloproteid supply from blood flow. The alveolar EPR spectra of patients with chronic tonsillitis show Cu^{2+}, Fe^{3+} and FR signals. Vasomotor rhinitis is accompanied with a reduced Fe^{3+} level in nasal secretion.

xviii) Diseases of Teeth and Mouth Cavity

EPR spectroscopy is widely used in stomatology to elucidate the mechanisms governing the development of teeth and mouth cavity lesions. A correlation exists between the EPR parameters, size of wound are and frequency of post-extraction inflammatory disorders.

...The EPR method is suitable for in vivo temperature measurements basing on the temperature response of nitroxide stable free radicals. This temperature measuring method has various potential clinical applications, especially in monitoring and optimizing the treatment of cancer with hyperthermia...

xix) Radiation - Induced Pathology

The radiation (g and X-ray) dose absorbed by the victims of accidents can be determined by using the EPR method by a FR signals of bone, dentine and tooth enamel.

xx) Hyperthermia in Pathologic States

The EPR method is suitable for in vivo temperature measurements basing on the temperature response of nitroxide stable free radicals. This temperature measuring method has various potential clinical applications, especially in monitoring and optimizing the treatment of cancer with hyperthermia.

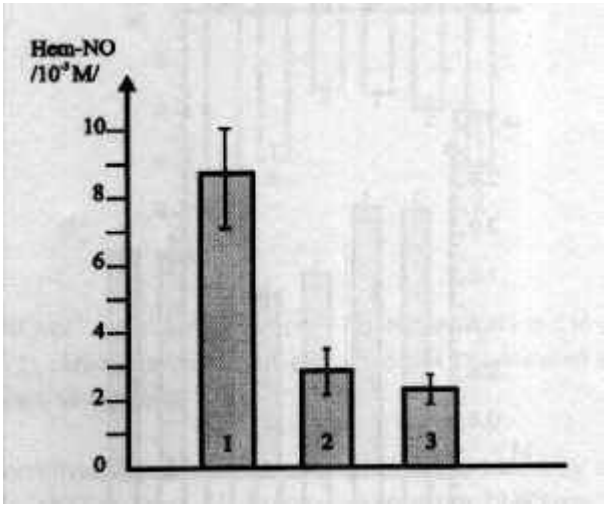
xxi) Hyperbaric Oxygenation

Blood from patients undergoing hyperbaric oxygen exposure have shown marked increase in free radicals as seen by EPR spectroscopy.

xxii) Conditions under Narcosis

Narcotics-induced biochemical alterations occurring in the host organism have been studied by EPR spectroscopy. There is a decrease in plasma SOD like activity under surgery independently of the type of anaesthesia, the anesthetic agent used and the degree of surgical invasion.

Intestinal Hem-NO concentration (10^{-5} M) in donors (1) and in patients with chronic gastritis (2) and gastric-duodenal ulcer (3). This figure appears on page 125 of the book.



xxiii) Pathologic States caused by Intoxication

Toxicological influence of heavy metal ions and free radicals was examined using the EPR method. Copper and mercury ions increase the human erythrocyte membrane lipid bilayer rigidity.

xxiv) Sepsis - Induced States

Xanthine oxidase activity and lipid peroxidation were increased in septic patients.

xxv) Peritonitis

The methemoglobin level in plasma depends on the severity of state. The highest concentration appears on the second to fifth day and later it is decreased.

xxvi) Acquired Immunodeficiency Syndrome (AIDS)

Polypeptide aggregation with cells by the glycoprotein N-terminal residue (gp 41) is suggested to be involved in HIV-induced fusion and cytolysis.

4. Other aspects of EPR investigation of biological specimens

The development of new technique particularly with the use of spin probes and spin labels, has extended the capabilities of studying the biological specimens using EPR. This resulted in the increase in the number of investigations of both the materials obtained from humans in various pathological states, and food products, medicines and other biological objects.

...EPR finds use in determination of the archaeological age of human bone remnants on the basis of detection of free radicals. EPR data established the existence of anatomically contemporary man over 100 ka years ago in Israel and Africa. Remains of even earlier age were revealed in China. Tooth enamel EPR examination has found much use of dating the biological and cultural evolution of modern man. About 60 years have gone since the discovery of EPR by E.K. Zavoisky. During this

time EPR spectroscopy has provided a widely accepted method in both clinical practice and laboratory investigations...

i) Food products

EPR spectroscopy was used to study the difference between red and white wines/between concentrates of red grapes and white grapes. The FR scavenging activity of the Japanese herbal medicine, Toki-Shakuyaku-San and BG-104 (a compound of Chinese herbs) has also been studied. EPR spectroscopy provides a very convenient precision instrument to determine stable FR concentrations on radiation - exposed food (meat and fish bones, marine products, fruits, vegetables).

ii) Drugs

EPR spectroscopy has been used to study the anti-oxidant activity of drugs like berbamine, kampo medicines, baicalin, flavonoids and rebapimide. The pharmacokinetic and pharmacodynamic of drugs have been studied e.g. gramicidin A, tetracyclines, indomethacin, anticancer drugs, omeprazole etc. It is also helpful in relieving side effects of treatment with some drugs like organic nitrates, vitamins C and E, sympathomimetics, etc.

iii) Forensic Medical Examination

EPR method has been used in the estimation of time of death upto 8 months postmortem.

iv) Archaeology

EPR finds use in determination of the archaeological age of human bone remnants on the basis of detection of free radicals. EPR data established the existence of anatomically contemporary man over 100 ka years ago in Israel and Africa. Remains of even earlier age were revealed in China.

...The present book will enhance interest in clinical aspects of the use of EPR spectroscopy and initiate new research and developments supplementing and illustrating the role of paramagnetic centers in the organisms. It will also convince biochemists and clinicians of the necessity of using spectroscopy in clinical practice and research based on the evidence on the limitless possibilities of the use of EPR spectroscopy in biochemistry and medicine...

Tooth enamel EPR examination has found much use of dating the biological and cultural evolution of modern man.

About 60 years have gone since the discovery of EPR by E.K. Zavoisky. During this time EPR spectroscopy has provided a widely accepted method in both clinical practice and laboratory investigations. The literature discussed in this book and the present authors' results indicate much promise for EPR spectroscopy in biochemistry, biology and medicine. The potential of this method would be increased greatly when used in enzymology in combination with spectrophotometry, multinuclear NMR, chemiluminescence and other physico-chemical methods.

The EPR method extends our knowledge of the role of transition microelements in vital activities of man, provides an understanding of the thin mechanisms of pathogenic processes of various diseases and offers a great promise for new therapeutic and prophylactic measures.

The present book will enhance interest in clinical aspects of the use of EPR spectroscopy and initiate new research and developments supplementing and illustrating the role of paramagnetic centers in the organisms. It will also convince biochemists and clinicians of the necessity of using

spectroscopy in clinical practice and research based on the evidence on the limitless possibilities of the use of EPR spectroscopy in biochemistry and medicine.



-Sherin S. Thomas

Sherin S. Thomas is currently working as a Senior Resident in the Department of Biochemistry at the Maulana Azad Medical College, New Delhi. She completed her MBBS (graduation in medicine and surgery) in 1994 and completed her specialization (MD in Biochemistry) in 2001.

Dr. Thomas is an avid reader of books, journals etc. on a wide variety of topics, especially on Brain theory and neural networks and Computational Molecular Biology. She is a passionate book lover. Her other interests include listening to music and spending time with her five cats and three dogs.

Order this book by clicking here

Request a PDF file of this review by clicking here. (If your screen resolution can not be increased, or if printing this page is giving you problems like overlapping of graphics and/or tables etc, you can take a proper printout from a pdf file. You will need an Acrobat Reader though.)

Visit official site of Kluwer Academic by clicking here.

[Aims and Objectives] [FAQ] [Editorial Board] [Contributing Partners] [Sitemap]
[Paper/Thesis submission guidelines] [Editorials - Cumulative Index] [Be our sponsor!]

[Cumulative index of Book Reviews sorted by | Publishers | General Interest Books | Technical Books] [Animated Reviews] [Featured Reviews]

[Links] [Submit books/journals/software/multimedia for review] [journal CD] [History of the Journal] [Interviews] [Credits]

[Online Courses] [Awards] [Anil Aggrawal's Internet Journal of Book Reviews - Sister Publication]

[Cumulative reviews of Software/Multimedia | Books on CD/Audio tapes] [contact us]