PREFACE

The development of computational and mathematical methods facilitated the formalization of many medical profession aspects. The computer aided diseases diagnostics has turned out to be one of the most important and significant application in medical sciences. Applications of multi-factor computer based mathematical techniques to the diagnostic of the cancer, cardiovascular and rheumatologic infections have proved to be of principal significance.

Various biophysical methods have been developed for the diagnostics of the cancer disease. Among them the thermography has the great appeal due to its non-destructive nature in comparison to other procedures/methods. Thus, modelling and simulation of thermal problems of human body becomes interesting due to its thermographic applications. Further, the thermal information of the human body tissues is also useful for hyperthermic applications such as development of bio-physical methods for killing tumor cells by regional/local heating. Modelling and simulation can be used as a tool to study the temperature variation in tissues and their relationship with other parameters involved in the temperature regulation in human body under normal and abnormal conditions. The results of this study will shed light on the factors which influence the temperature variance of normal and malignant tissues in thermography and hyperthermia. In view of the above, I found an interest in the subject and decided to pursue my Ph.D. work on the topic “Mathematical analysis of the heat and mass transfer in biological tissues with special reference to tumors”. The study has been carried out by me at the Department of Mathematics, University of Kashmir, Srinagar. The study is based on establishing various mathematical models in human physiology to study heat and mass transfer under normal and adverse conditions. Finite difference method, Finite element method, Eigenvalue method, etc., were used for the solution purpose of the formulated models. A short chapter wise description is given below.

The first chapter deals with the bio-physical aspects of thermo-regulation of the human body. The topics like heat-regulation in biological tissues, structure of the skin, blood flow and its role in thermo-regulation, tumor and its classifications. Also almost all the bio-physical processes taking place in normal and malignant tissues were extensively discussed in this chapter.

The second chapter is devoted to the mathematical background required for the establishment of solutions to the formulated models in the subsequent chapters of the thesis. The formulation and the brief description of the solution processes are also explained in this chapter. The use of solutions like finite difference method, finite element method, variational finite element method were thoroughly discussed in this chapter. The elementary concepts of MATLAB software have also been incorporated in this chapter, which are used for the simulation purpose of the formulated models.

The third chapter is divided into two sections. In the first section, the linear type of Pennes’ bio-heat equation has been discussed. The role of atmospheric temperature on the thermo-regulation of the skin has been studied. The second section is devoted towards the study of non-linear bio-heat equation. In this case, the effect of the ambient conditions on the temperature profiles of the human head has been
estimated.

In fourth chapter, the diffusion of heat through biological tissues has been studied. The main focus was given to study heat transport in dermal regions with tumor in subcutaneous part of the dermal region. The estimation of temperature regulation was done using variational finite element method over linear and triangular elements for one and two dimensional models respectively.

The fifth chapter describes the process of mass diffusion in the biological tissues using non-dimensional analysis for the formulation of the model. Eigenvalue approach was used to solve the formulated model. In this chapter the role of anti-tumor drug concentration in the tumor tissue at various initial concentrations of the drug and at different rate constants has been discussed.