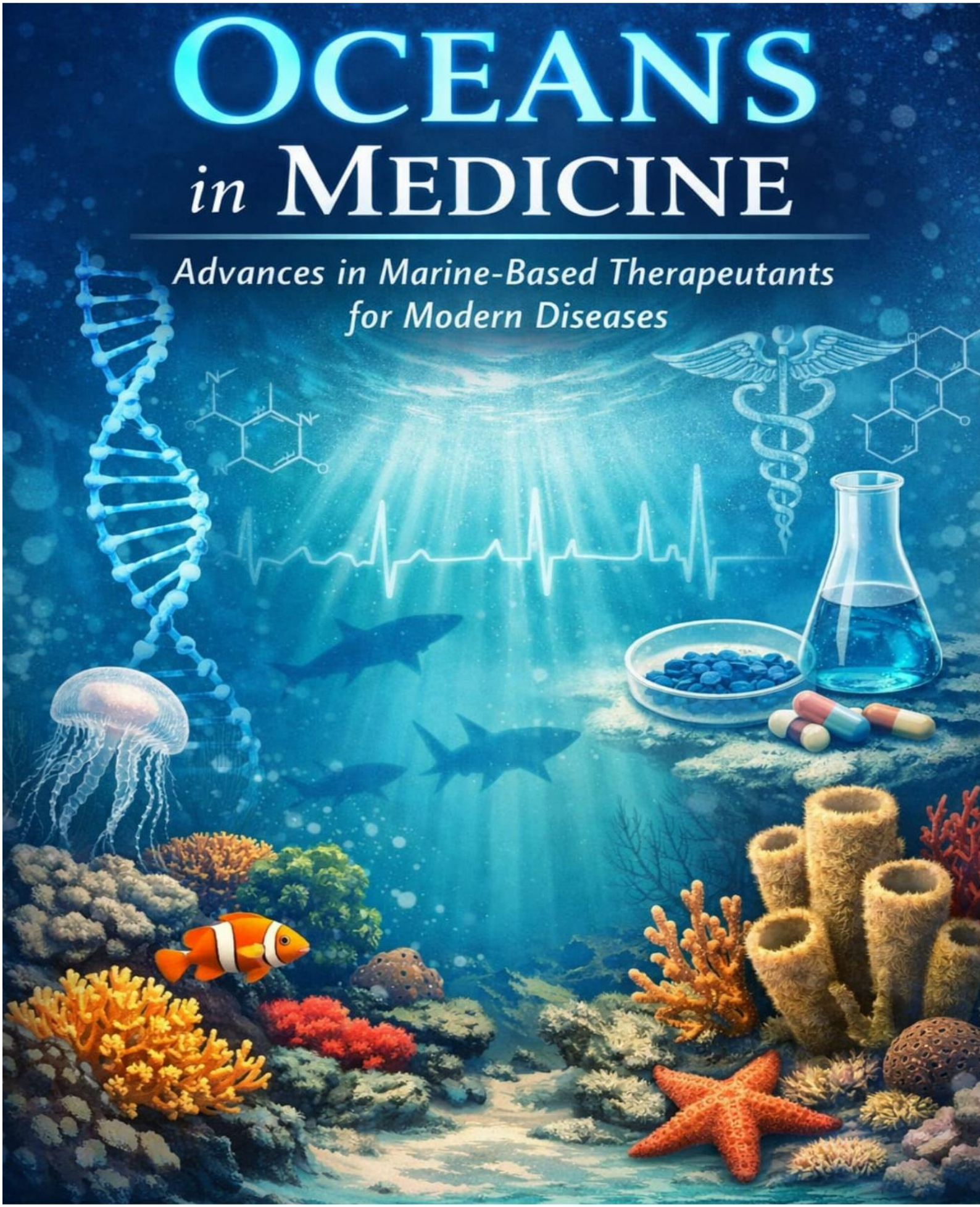
OCEANS in MEDICINE

Advances in Marine-Based Therapeutants for Modern Diseases



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Chapter 7: Astaxanthin from Marine Microalgae: Antioxidant and Cardioprotective Applications in Metabolic Diseases

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Abstract

Astaxanthin, a xanthophyll carotenoid predominantly derived from marine microalgae, has emerged as a potent bioactive compound with significant antioxidant and cardioprotective properties. Metabolic diseases, including obesity, type 2 diabetes mellitus, dyslipidemia, and metabolic syndrome, are closely associated with oxidative stress, chronic low-grade inflammation, endothelial dysfunction, and impaired lipid and glucose metabolism. Astaxanthin exhibits exceptional free radical scavenging activity, membrane-stabilizing effects, and the ability to modulate redox-sensitive signaling pathways such as Nrf2, NF-κB, and MAPK. Preclinical and clinical studies demonstrate that astaxanthin improves insulin sensitivity, attenuates lipid peroxidation, reduces inflammatory biomarkers, and protects cardiovascular tissues by enhancing endothelial function and preventing low-density lipoprotein oxidation. Marine microalgae, particularly *Haematococcus pluvialis*, represent a sustainable and commercially viable source of natural astaxanthin with superior bioactivity compared to synthetic forms. This chapter comprehensively discusses the sources, biosynthesis, physicochemical properties, antioxidant mechanisms, and cardiometabolic benefits of microalgal astaxanthin, highlighting its therapeutic potential in the prevention and management of metabolic diseases. Current challenges, formulation strategies to enhance bioavailability, and future research directions are also addressed to support its translational and clinical application.

Keywords: Astaxanthin, marine microalgae, antioxidant activity, cardioprotection, metabolic diseases, oxidative stress, inflammation, insulin resistance, dyslipidemia

1. Introduction

Metabolic diseases, including obesity, type 2 diabetes mellitus, metabolic syndrome, and dyslipidemia, represent a major global health burden and are strongly associated with increased cardiovascular morbidity and mortality. These disorders are characterized by