TEACHING INNOVATIONS IN LIPID SCIENCE

EDITED BY
Randall J. Weselake

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Preface

There is no uniformly adopted definition for lipids. William W. Christie has defined lipids as "fatty acids and their derivatives and substances related biosynthetically or functionally to these compounds" (http://www.lipidlibrary.co.uklipids/whatlipid/index.htm). Excellent detailed information on the chemistry and biochemistry of lipids and analysis of lipids can be found at the Lipid Library at this website.

Lipids touch our lives in a number of ways, including the improvement of oilseed crops, preparation of the foods and supplements we consume, multiple aspects of cellular function and human nutrition and issues surrounding our health, and as potentially valuable biofuels and biolubricants to solve environmental problems and provide alternatives to our dwindling petrochemical reserves. Lipid science, however, is often characterized as "unexciting," with students' becoming disenchanted from looking at textbook pages containing long hydrocarbon chains with equally unappealing scientific names. At the same time, the public is mystified at the ever-changing and nonuniform commentary about food choices containing lipids and the health effects of lipids in our foods. The impetus for *Teaching Innovations in Lipid Science* stems from a lively poster session on the same topic held at the Annual Meeting and Expo of the American Oil Chemists Society in Kansas City, Missouri in May 2003. In the months following the successful event, I contacted the contributors to the poster session and a few others about putting together a book that featured both strategies and experiments in teaching lipid science.

This book offers peer-reviewed contributions from lipid science specialists from Canada, the United States, the United Kingdom and Hong Kong. Section I focuses on teaching lipid science to the general public, students at various levels of education and instructors of lipid science. The section begins with a chapter that describes some of the barriers that lipid science specialists face in transmitting accurate information to the public. The next two chapters place a strong emphasis on the development and implementation of creative programs that foster an interest in lipid science, particularly at the high school level. Chapter 4 presents the creative problem-solving approaches that Dr. Karen Schaich has implemented in her lipid chemistry course at Rutgers University. Following this, strategies for involving independent study students at the undergraduate level in a range of lipid science projects are discussed. Methods for evaluating these students are presented along with some information on the career paths that they eventually chose. In Chapter 6, Dr. Lawrence Johnson and colleagues of the University of Iowa explain how sample cards can be used to teach undergraduates and graduate students about the processing of oilseeds and cereals. The final two chapters of this first section are mainly generalized accounts of biotechnology and crop improvement, and isoprenoid biochemistry, both of which may serve as useful resources to professors and other undergraduate instructors. The biotechnology chapter places a strong emphasis on the improvement of oilseed crops and provides some tips on explaining DNA science and crop biotechnology to the public.

Section II of *Teaching Innovations in Lipid Science* begins with two chapters featuring simple demonstrations on the physical properties of lipids that should be useful for teaching aspects of lipid science in middle- and high school classrooms. Chapters 11 to 13 present experiments for analyzing lipids in food oils, plasma and milk. It is anticipated that these chapters will provide a valuable resource for designing and offering lipid science labs at both the senior undergraduate and graduate student level. The chapters on lipid analysis include information on thin layer chromatography, gas chromatography and high performance liquid chromatography. In Chapter 14, Dr. Robert Moreau of the U.S. Department of Agriculture describes the use of convenient enzyme test kits for teaching lipid chemistry. Exercises involving one or more of these test kits could potentially be added to a lab course that begins with chromatographic methods for analyzing lipids. The final chapter in the book presents theory and experiments for studying lipid metabolism in the plant organelle known as the plastid in an area that straddles biochemistry and physiology. Drs. Salvatore Sparace and Kathryn Kleppinger-Sparace have extensive experience in working with plant plastids, the organelle that houses the process of fatty acid synthesis. Methods are described for preparing plant plastids, and studying metabolite uptake and pathway analysis. It is anticipated that this final chapter will represent a valuable resource for use in advanced undergraduate and graduate student labs.

Overall, *Teaching Innovations in Lipid Science* addresses lipid education at numerous levels ranging from educating the public to offering exciting experiments in lipid biochemistry to senior undergraduates and graduate students. We hope this book will inspire the lipid educator to use some of the approaches and methods presented in designing new courses or modifying existing courses. Above all, we hope that it will inspire readers to think about how this information could be used to disseminate lipid science knowledge for their specific purposes and serve as a basis for pursuing additional novel avenues of instruction.

About the Editor

Randall J. Weselake is currently a professor and Tier I Canada Research Chair in Agricultural Lipid Biotechnology with the Department of Agricultural, Food and Nutritional Science at the University of Alberta in Edmonton. He is also a guest researcher with the Plant Biotechnology Institute of the National Research Council of Canada in Saskatoon, Saskatchewan. Dr. Weselake received his doctorate in plant biochemistry from the Department of Plant Science at the University of Manitoba in Winnipeg in 1984. Research leading to his doctorate was conducted at the Grain Research Laboratory of the Canadian Grain Commission, also in Winnipeg. Although trained as a cereal biochemist, he became involved in plant lipid biochemistry when he joined the Plant Biotechnology Institute as a research associate in 1987. Two years later, he joined the Department of Chemistry and Biochemistry at the University of Lethbridge (Lethbridge, Alberta, Canada) where he continued to work in the area of lipid biochemistry for about 15 years. Dr. Weselake served as chair of the department from 1996–1999 and held a University of Lethbridge Board of Governors Research Chair from 2002 until he left for the University of Alberta in 2004. From 1999–2000, he was a visiting scholar in the Department of Biological Sciences at the University of Calgary in Alberta. Currently, at the University of Alberta, he oversees the research activities of eight graduate students, two postdoctoral researchers and a number of technical personnel. Dr. Weselake has designed a course in lipid science that is offered at both the undergraduate and graduate level.

A large component of the projects and programs led by Dr. Weselake focuses on the development of molecular strategies to enhance seed oil content in canola and modify the fatty acid composition of oil from canola and flax. He has also been involved in the development of biochemical and molecular markers for the marbling trait (intramuscular fat) in beef cattle, and investigations of conjugated linoleic acid in milk fat from dairy cattle and the effect of these fatty acid isomers on milk fat synthesis. Dr. Weselake collaborates extensively with other researchers in Canada, the United States and Europe. His research is supported by provincial and national funding agencies, and, recently, his work has begun to attract the interest of major industries in the plant biotechnology area. Currently, he is serving as the co-leader of the large-scale functional genomics project, "Designing Oilseeds for Tomorrow's Markets," which is funded by Genome Canada, Genome Alberta and partners. Recently, he became the leader of the large-scale "Bioactive Oils Program" funded by AVAC Ltd. (Alberta) and partners. Dr. Weselake is the author of 87 publications in peer-reviewed journals and book chapters, and has delivered about 50 invited presentations at various conferences and other venues. Within the last eight years, he has published eight invited reviews dealing with various aspects of storage lipid synthesis in plants. He has been serving as an associate editor of the journal *Lipids* since 2005.

Currently, Dr. Weselake is a member of the American Oil Chemists Society (AOCS), Canadian Section of the American Oil Chemists Society (CAOCS), Amer-

ican Society of Plant Biology and Canadian Society of Plant Physiologists. He has been a member-at-large of the governing board and the Biotechnology Division of the AOCS since 2004. He served as president of the CAOCS from 2003–2005 and was technical chairperson for the Annual Meeting and Expo of the AOCS held in Montréal in May 2002. Dr. Weselake has been involved in a number of committees dealing with the adjudication of grant applications and research programs. This year he served as a member of the Plant Research Panel for Agriculture and Agri-Food Canada and currently serves (since 2005) as a member of the Scientific Committee for the large-scale Green Crop Network funded by the Natural Sciences and Engineering Research Council of Canada.

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Section I

Strategies for Teaching Lipid Science to the Public, Students and Teachers

1 Educating the Public about Lipids

Anthony H.C. Huang and Randall J. Weselake*

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1.1 CURRENT AVENUES FOR TRANSMITTING LIPID KNOWLEDGE TO THE PUBLIC

It is an opportune time for lipid researchers and educators. Concerns about lipid consumption and the role of lipids in health are foremost in the minds of the public. In the U.S., Canada and other developed countries, obesity and being overweight have become major health problems. Coronary artery and peripheral vascular diseases are the major causes of death. The problem not only impinges on physical health, but also induces stigmatization and discrimination in society. Obesity and being overweight have also spread to many fast-developing countries, including China and Brazil, as their populations become more affluent. In the U.S., in response to consumer interest and new advances in lipid research, the U.S. Food and Drug Administration (USFDA) continues to implement new regulations for labeling food products, especially describing the content and type of lipid in food. "Fast food" and traditional restaurants, in particular franchises, have revised their menus to become more attractive to health-conscious consumers, with many of their menus revealing the content and type of lipids in each item. Consumers are reading food labels more carefully than ever before and deciding on what they should purchase and eat in accordance with what they perceive as good for their health. Topping the current list of interests are concerns about *trans* fatty acids, percentage saturation, *omega*-3 fatty acids, fat-free products and low-fat products. Some people readily admit that they know very little about lipids and have acquired the ideas of "good" or "bad"

* Corresponding author.

fats from friends or heard or read by chance information from a certain source. Others, convinced they are knowledgeable because of the substantial efforts spent obtaining information from the media, can proclaim this or that food product to be good or bad because of its content of a certain fat. They often sound like experts, but are they?

Unfortunately, the public is far from being expert, or for that matter, well informed about lipids in foods. Most of the public lacks a background in science, let alone chemistry and biology. Whatever science they learned in grade school or college may have little retention in their memories. Those with more curious minds pay attention to what they read, hear and watch. Most look for information on food and health from the media. A 1999 survey by the American Dietetic Association revealed that the public receives information about food and health primarily from the media, such as television and magazines, and secondarily from dietitians and medical doctors.[1] Diligent people try to read extensively and likely encounter a large volume of similar information, but are eventually indoctrinated without knowing that the various items of information might all have come from a single syndicated media source.

Media reporters are well aware of the public's interest and try to convey scientific information as best as they can. Although not always intended, they play a major role in our health, because they strongly influence what we want, and in turn, what the food industry advertises and delivers. Most reporters, however, lack an in-depth knowledge of chemical and biological sciences. Many reporters probably majored in the humanities in college, for a training that sharpened their broad social knowledge, writing skills and ability to disseminate information. We may be asking too much of a reporter to comprehend the details of scientific issues, especially controversial subjects such as fats and health. Thus, media reports are often easily misunderstood by the public. In a situation less known to the outside world, reporters often face internal competition within the media organization for their reports to be chosen for use in a prestigious segment of the media. As a consequence, they write simplified explanations and attempt to make the subjects such as fats and health exciting and pertinent to the public. Often, the information has been oversimplified to the point of being incorrect or even more difficult to comprehend. Minor points raised in the interview of a scientist sometimes become overemphasized or exaggerated in the media article, and thus the report distorts the information the scientist had intended to transmit to the public. Some reporters, especially those in high-profile media, are more conscientious or are required to have reports checked by experts, which include dietitians, doctors, industrial scientists and university professors.

Dietitians and medical doctors are the main sources reporters consult for expert health/dietetic information. They are also the most direct source, ranked after the media, of information for the general public.[1] Most dietitians probably read extensively, but may lack an in-depth knowledge of scientific concepts that would allow them to discriminate among confusing and biased media information and scientific reports (e.g., results of short-term or statistically questionable studies). Although medical doctors receive substantially more professional training than dietitians, their exposure, except for some specialists, to human nutrition is limited. In the U.S.

and Canada, most patients first encounter their family doctors, the "gatekeepers," before seeing specialists. In general, primary care doctors are trained to comprehend broad personal health situations, but not the "nuts and bolts" of specific fields such as fats and health, and especially not the latest advances in the fields. Their focus is on diagnosing and treating diseases with technical approaches. How many primary care doctors know the structure of an omega-3 fatty acid, let alone know the basis for this fatty acid nomenclature? Most primary care doctors are overworked and have little time to carefully examine issues about food (fats) and health and actually acquire the information from the media, just as their patients do. When asked about a certain fat in relation to health, primary care doctors either try to answer the question authoritatively or refer the patient to a dietitian. Many patients are therefore convinced they were properly informed by an expert. Ironically, most commercials on fats or drugs, as legal protection from claims, routinely urge potential consumers to ask a doctor's advice.

Scientists in the lipid field are often asked by reporters about lipids and health in depth. Some provide sound advice while others, while knowledgeable, could be biased in their statements or have a conflict of interest. A 2003 survey by the Health and Nutrition Division of the American Oil Chemists Society (AOCS) asked division members about their preferences for lipid-containing foods.[2] A high percentage of these experts recommended the food that they were most familiar with or were doing research on.

1.2 INTERWOVEN NETWORKS OF INFORMATION AND MISINFORMATION

Overall, the public is educated about fats in food products from an interwoven network of uninformed or underinformed media reporters, medical professionals, potentially biased scientists and politically influenced government agencies. These sources together generate an apparent consensus, all of which might have come from one or a few primary sources. Some of the claims are valid, whereas the others are debatable or oversimplified. On top of these sources are biased and ubiquitous commercials whose primary objective is to sell products. Added to the commercials are the food labels, which are government mandated.[3] Many food companies try to present the information in creative ways and exploit loopholes in regulations. For example, a high-lipid coffee cream is labeled as "fat free" only because the manufacturer cuts down the suggested serving size, so that the lipid content per serving becomes less than 0.5 g, which can then be rounded to 0.

Although general trends on the effects of the fat composition of food on health have emerged in the scientific literature,[4] lipid research carried out by different groups around the world often produces results on the effects of lipids on animal and human health that may not be in agreement. In addition, new findings in lipid nutrition are often accompanied by press releases, thereby providing new information for the media. Thus, the public becomes even more confused about the effects of lipids on health. It is important that an individual does not tailor his or her lipid intake based on a single media report about a new finding, but that the individual is encouraged to seek out further information from other sources.