THIRD EDITION

The Vitamins

Fundamental Aspects in Nutrition and Health

Gerald F. Combs, Jr.

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Third Edition

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To Henry

Preface

I am delighted to have the chance of producing a third edition of *The Vitamins*. Because the previous editions were well received, I have not changed the basic format in writing this edition. *The Vitamins* remains a book designed for use in an academic course on the topic; thus, I retained its conceptual orientation. But the book is also intended to serve as a ready reference for nutritionists, dieticians, food scientists, clinicians, and other professionals in the biomedical and health communities. For this reason, I have expanded its depth of coverage in several areas, particularly those related to the health effects associated with vitamin status and/or use. In so doing, I also increased the documentation provided by footnoting important findings with citations from the primary literature. I made such revisions to each chapter based on recent research findings. Therefore, it is of interest to note that generally the chapters I expanded most were those to which I had made the most significant changes in preparing the second edition: vitamin A (5), vitamin D (6), vitamin E (7), vitamin C (8), and folate (16). To this list I add the chapters on quasi-vitamins (19) and quantifying vitamin requirements (20). I revised the coverage of the quasi-vitamins with an expanded discussion of flavonoids and a new section on non-provitamin A carotenoids (lycopene, xanthophylls, etc.) both of which areas are the subject of interesting current research. I completed the vitamin requirements chapters with expanded information about the Dietary Reference Intakes (DRIs), not all of which had been published by the time the second edition went to press.

I appreciate the supportive efforts of my editors, Chuck Crumley, Mara Conner, and Julie Ochs. Working with each has been a pleasure.

There is a saying that "to teach is to learn twice." I find that to be the case for writing a book of this nature; it is, after all, a form of teaching. So it is that I have taken from this effort an understanding about the vitamins much deeper than I could otherwise have gained. Certainly, that justifies the weekends and evenings spent wading through the stacks and stacks and stacks of scientific papers, books, and reviews filling my study. I enjoyed this work. I hope you will find it useful.

G. F. Combs, Jr.
Grand Forks, North Dakota
October 2006

The companion Web site containing an image collection, links, errata, and author information to complement the text can be found at http://books.elsevier.com/companions/9780121834937.

Preface to the Second Edition

Since writing the first edition of *The Vitamins*, I have had a chance to reflect on that work and on the comments I have received from Cornell students and from various other instructors and health professionals who have used it at other institutions. This, of course, has been an appropriately humbling experience that has focused my thinking on ways to improve the book. In writing the second edition I have tried to make those improvements, but I have not changed the general format, which I have found to facilitate using the book as a classroom text.

Those familiar with the first edition will find the revision to be expanded and more detailed in presentation in several ways. The most important changes involve updating to include new information that has emerged recently, particularly important findings in the areas of molecular biology and clinical medicine. This has included the addition of key research results, many in tabular form, and the expansion of the footnote system to include citations to important research papers. The reference lists following each chapter have been expanded, but these citations include mainly key research reviews, as in the first edition. While each chapter has been expanded in these ways, the most significant changes were made in the chapters on vitamin A (5), vitamin D (6), vitamin E (7), vitamin C (8), and folate (16), which areas have experienced the most rapid recent developments. Some smaller changes have been made in the structures of the vitamin chapters (5–18): each has been given an internal table of contents; an overview of the general significance of the vitamin in nutrition and health has been included; the topics of deficiency and toxicity are discussed under separate headings.

Perhaps the most striking aspect of the second edition will be its professional layout. That reflects the contributions of the editors and staff at Academic Press. They have made of this revision a book that is not only more handsome but also, I believe, easier to use than was the first edition which I laid out on my own computer. I am grateful to Charlotte Brabants and Chuck Crumley, who handled *The Vitamins*, for their professionalism and for their patience. I am also grateful to my wife, Dr. Barbara Combs, for her suggestions for the design and use of a teaching text in a discussion-based learning environment, as well as for her understanding in giving up so many weekends and evenings to my work on this project

The Vitamins remains a book intended for use by nutrition instructors, graduate students in nutrition, dietetics, food science and medicine, clinicians, biomedical scientists, and other health professionals. It can be used as a teaching text or as a desk reference. It is my hope that it will be used—that it will become one of those highly annotated, slightly tattered, note-stuffed volumes that can be found on many bookshelves.

G. F. Combs, Jr.
Ithaca, New York
August 1997

Preface to the First Edition

I have found it to be true that one learns best what one has to teach. And because I have had no formal training either in teaching or in the field of education in general, it was not for several years of my own teaching that I began to realize that the good teacher must understand more than the subject matter of his or her course. In my case, that realization developed, over a few years, with the recognition that individuals learn in different ways and that the process of learning itself is as relevant to my teaching as the material I present. This enlightenment has been for me invaluable because it has led me to the field of educational psychology from which I have gained at least some of the insights of the good teacher. In fact, it led me to write this book.

In exploring that field, I came across two books that have influenced me greatly: *A Theory of Education*[1] by another Cornell professor, Joe Novak, and *Learning How to Learn*[2] by Professor Novak and his colleague Bob Gowin. I highly recommend their work to any scientific "expert" in the position of teaching within the area of his or her expertise. From those books and conversations with Professor Novak, I have come to understand that people think (and, therefore, learn) in terms of *concepts*, not facts. Therefore, for the past few years I have experimented in offering my course at Cornell University, "The Vitamins," in ways that are more concept-centered than I (or others, for that matter) have used previously. While I regard this experiment as an ongoing activity, it has already resulted in my shifting away from the traditional lecture format to one based on open classroom discussions aimed at involving the students, each of whom, I have found, brings a valuable personal perspective to discussions. I have found this to be particularly true for discussions concerning the vitamins; while it is certainly possible in modern societies to be misinformed about nutrition, it is virtually impossible to be truly naive. In other words, every person brings to the study of the vitamins some relevant conceptual framework and it is, thus, the task of the teacher to build upon that framework by adding new concepts, establishing new linkages and modifying existing ones where appropriate.

It quickly became clear to me that my own notes, indeed, all other available reference texts on the subject of the vitamins, were insufficient to support a concept-centered approach to the subject. Thus, I undertook to write a new type of textbook on the vitamins, one that would be maximally valuable in this kind of teaching. In so doing, I tried to focus on the key concepts and to make the book itself useful in a practical sense. Because I find myself writing in virtually any book that I really use, I gave this text margins wide enough for the reader to do the same. Because I have found the technical vocabularies of many scientific fields to present formidable barriers to learning, I have listed what I regard as the most important technical terms at the beginning of each chapter and have used each in context. Because I intend this to be an accurate synopsis of present understanding but not a definitive reference to the original scientific literature, I have cited only current major reviews that I find useful to the student. Because I have found the discussion of real-world cases to enhance learning of the subject, I have included case reports that can be used as classroom exercises or student assignments. I have designed the text for use as background reading for a one-semester upper-level college course within a nutrition-related curriculum.

[1] Cornell University Press, Ithaca, NY, 1977, 324 pp.

[2] Cambridge University Press, New York, 1984, 199 pp.

In fact, I have used draft versions in my course at Cornell as a means of refining it for this purpose.

While *The Vitamins* was intended primarily for use in teaching, I recognize that it will also be useful as a desk reference for nutritionists, dieticians and many physicians, veterinarians, and other health professionals. Indeed, I have been gratified by the comments I have received from colleagues to that effect.

It is my hope that *The Vitamins* will be read, reread, written in, and thought over. It seems to me that a field as immensely fascinating as the vitamins demands nothing less.

G. F. Combs, Jr.
Ithaca, New York
August 1991

How to Use This Book

The Vitamins is intended as a teaching text for an upper-level college course within a nutrition or health-related curriculum; however, it will also be useful as a desk reference or as a workbook for self-paced study of the vitamins. It has several features that are designed to enhance its usefulness to students as well as instructors.

To the Student

Before reading each chapter, take a few moments to go over the ***Anchoring Concepts*** and ***Learning Objectives*** listed on the chapter title page. *Anchoring Concepts* are the ideas fundamental to the subject matter of the chapter; they are the concepts to which the new ones presented in the chapter will be related. The *Anchoring Concepts* identified in the first several chapters should already be very familiar to you; if they are not, then it will be necessary for you to do some background reading or discussion until you feel comfortable in your understanding of these basic ideas. You will find that most chapters are designed to build on the understanding gained through previous chapters; in most cases, the *Anchoring Concepts* of a chapter relate to the *Learning Objectives* of previous chapters. Pay attention to the *Learning Objectives*; they are the key elements of understanding that the chapter is intended to support. Keeping the *Learning Objectives* in mind as you go through each chapter will help you maintain focus on the key concepts. Next, read through the ***Vocabulary*** list and *mark* any terms that are unfamiliar or about which you feel unsure. Then, as you read through the text, look for them; you should be able to get a good feel for their meanings from the contexts of their uses. If this is not sufficient for any particular term, then you should consult a good medical or scientific dictionary.

As you go through the text, note what information the layout is designed to convey. First, note that the major sections of each chapter are indicated with a bold heading above a bar, and that the wide left margin contains key words and phrases that relate to the major topic of the text at that point. These features are designed to help you *scan* for particular information. Also note that the footnoted information is largely supplementary but not essential to the understanding of the key concepts presented. Therefore, the text may be read at two levels: at the basic level, one should be able to ignore the footnotes and still get the key concepts; at the more detailed level, one should be able to pick up more of the background information from the footnotes.

Chapters 5–17 are each followed by a ***Case Study*** comprised of one or more clinical case reports abstracted from the medical literature. For each case, use the associated questions to focus your thinking on the features that relate to vitamin functions. As you do so, try to ignore the obvious connection with the subject of the chapter; put yourself in the position of the attending physician who was called upon to diagnose the problem without prior knowledge that it involved any particular nutrient, much less a certain vitamin. You may find the additional case studies in Appendix B similarly interesting.

Take some time and go through the ***Study Questions and Exercises*** at the end of each chapter. These, too, are designed to direct your thinking back to the key concepts of each chapter and to facilitate integration of those concepts with those you already have. To this end, you are asked in this section of several chapters to prepare a *concept map* of the subject matter. Many people find the *concept map* to be a powerful learning tool; therefore, if you have had no previous experience with this device, then it will be

well worth your while to consult *Learning How to Learn*.[1]

At the end of each chapter is a reading list. With the exception of Chapter 2, which lists papers of landmark significance to the discovery of the vitamins, the reading lists consist of key reviews in prominent scientific journals. Thus, while primary research reports are not cited in the text, you should be able to trace research papers on topics of specific interest through the reviews that are listed.

Last, but certainly not least, have *fun* with this fascinating aspect of the field of nutrition!

To the Instructor

I hope you will find this format and presentation useful in your teaching of the vitamins. To that end, some of my experiences in using *The Vitamins* as a text for my course at Cornell may be of interest to you.

I have found that *every* student comes to the study of the vitamins with *some* background knowledge of the subject, although those backgrounds are generally incomplete, frequently with substantial areas of no information and misinformation. This is true for upper-level nutrition majors and for students from other fields, the difference being largely one of magnitude. This is also true for instructors, most of whom come to the field with specific expertise that relates to only a subset of the subject matter. In addition, I have found that, by virtue of having at least *some* background on the subject and being motivated by any of a number of reasons to learn more, *every* student brings to the study of the vitamins a unique perspective that may not be readily apparent to the instructor.

I am convinced that meaningful learning is served when both instructor and students come to understand each others' various perspectives. This has two benefits in teaching the vitamins. First, it is in the instructor's interest to know the students' ideas and levels of understanding concerning issues of vitamin need, vitamin function, and the like, such that these can be built upon and modified as may be appropriate. Second, I have found that many upper-level students have interesting experiences (through personal or family histories, their own research, information from other courses, etc.) that can be valuable contributions to classroom discussions, thus mitigating against the "instructor knows all" notion, which we all know to be false. To identify student perspectives, I have found it useful to assign on the first class period for submission at the second class a written autobiographical sketch. I distribute one I wrote for this purpose, and I ask each student to write "as much or as little" as he or she cares to, recognizing that I will distribute copies of whatever is submitted to each student in the class. The biographical sketches that I see range from a few sentences that reveal little of a personal nature to longer ones that provide many good insights about their authors; I have found *every one* to help me get to know my students personally and to get a better idea of their understandings of the vitamins and of their expectations of my course. The exercise serves the students in a similar manner, thus promoting a group dynamic that facilitates classroom discussions.

I have come to use *The Vitamins* in my teaching as the text from which I make regular reading assignments, usually a chapter at a time, as preparation for each class, which I generally conduct in an open discussion format. Long ago, I found it difficult, if not impossible, to cover in a traditional lecture format all of the information about the vitamins I deemed important for a nutritionist to know. Thus, I have put that information in this text and have shifted more of the responsibility for learning to the student for gleaning it from reading. I use my class time to assist the student by providing discussions of issues of particular interest or concern. Often, this means that certain points were not clear upon reading or that the reading itself stimulated questions not specifically addressed in the text. Usually, these questions are nicely handled by eliciting the views and understandings of other students and by my giving supplementary information. Therefore, my class preparation involves the collation of research data that will supplement the discussion in the text and the identification of questions that I can use to initiate discussions. In developing my questions, I have found it useful to prepare my own concept maps of the subject matter and to ask rather simple questions about the linkages between concepts, for example, "How does the mode of enteric absorption of the tocopherols relate to what we know about its physiochemical properties?" If you are unfamiliar with concept mapping, then I strongly recommend your consulting *Learning*

[1] Novak, J. D., and Gowin, D. B. (1984). *Learning How to Learn*. Cambridge University Press, New York, 199 pp.

How to Learn and experimenting with the technique to determine whether it can assist you in your teaching.

I have found it useful to give weekly written assignments for which I use the ***Study Questions and Exercises*** or ***Case Studies***. In my experience, regular assignments keep students focused on the topic and prevent them from letting the course slide until exam time. More importantly, I believe there to be learning associated with the thought that necessarily goes into these written assignments. In order to support that learning, I make a point of going over each assignment briefly at the beginning of the class at which it is due, and of returning it by the *next* class with my written comments on *each* paper. You will find that the *Case Studies* I have included are abstracted from actual clinical reports; however, I have presented them without some of the pertinent clinical findings (e.g., responses to treatments) that were originally reported, in order to make of them learning exercises. I have found that students do well on these assignments and that they particularly enjoy the *Case Studies*. For that reason, I have included in the revised edition additional case studies in Appendix B; I encourage you to use them in class discussions.

I evaluate student performance on the basis of class participation, weekly written assignments, a review of a recent research paper, and either one or two examinations (i.e., either a final or a final plus a midterm). In order to allow each student to pursue a topic of specific individual interest, I ask them to review a research paper published within the last year, using the style of *Nutrition Reviews*. I evaluate each review for its critical analysis as well as on the importance of the paper that was selected, which I ask them to discuss. This assignment has also been generally well received. Because many students are inexperienced in research and thus feel uncomfortable in criticizing it, I have found it helpful to conduct in advance of the assignment a discussion dealing with the general principles of experimental design and statistical inference. Because I have adopted a concept-oriented teaching style, I long ago abandoned the use of short-answer questions (e.g., "Name the species that require dietary sources of vitamin C") on examinations. Instead, I use brief case descriptions and actual experimental data and ask for diagnostic strategies, development of hypotheses, design of means of hypothesis testing, interpretation of results and the like. Many students may prefer the more traditional short-answer test; however, I have found that such inertia can be overcome by using examples in class discussions or homework assignments.

The Vitamins has been of great value in enhancing my teaching of the course by that name at Cornell. Thus, it is my sincere wish that it will assist you similarly in your teaching. I have been helped very much by the comments on the previous editions, which I have received both from my students and from instructors and others who have used this book. Please let me know how it meets your needs.

G. F. Combs, Jr.

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