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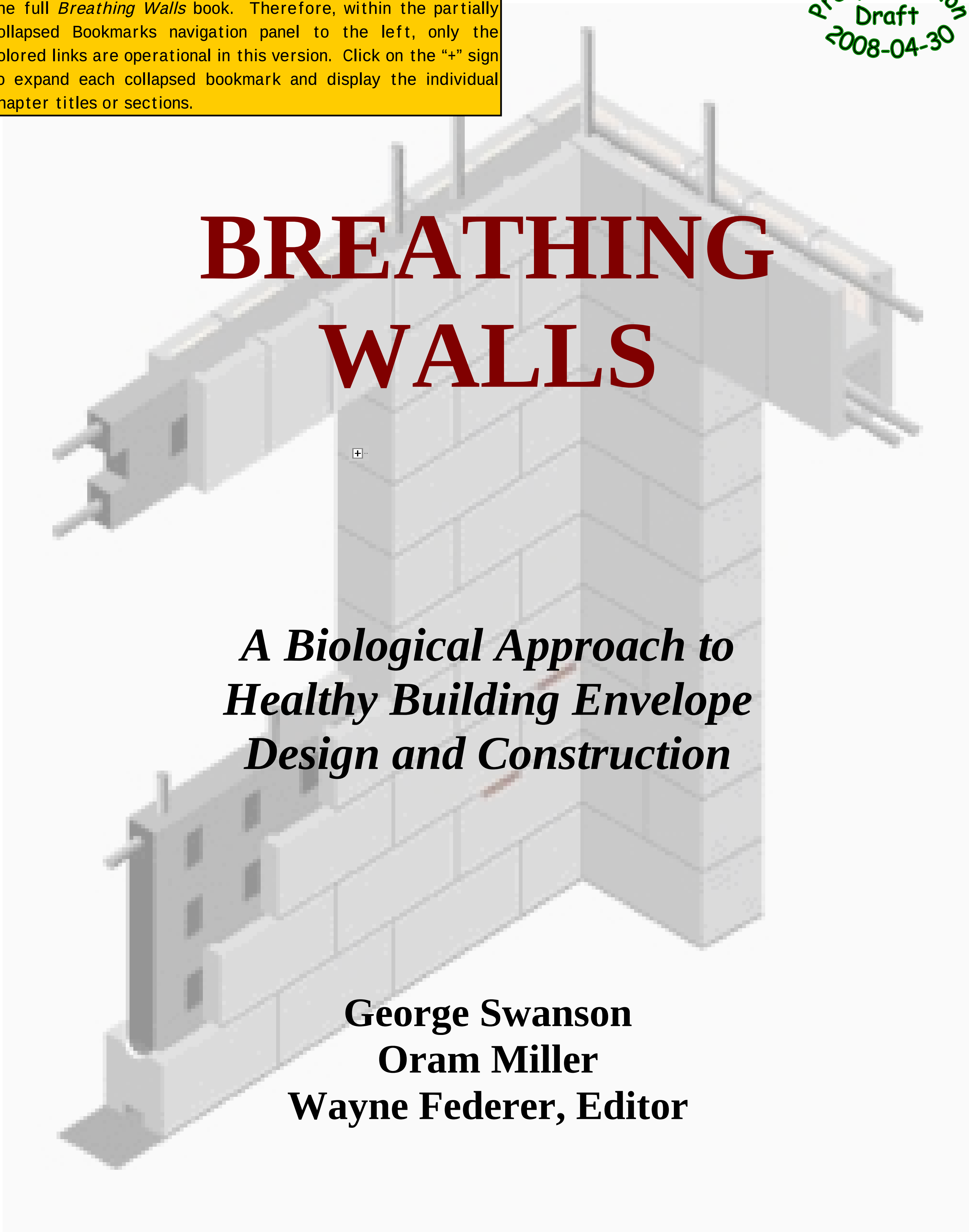

BREATHING WALLS

A Biological Approach to Healthy Building Envelope Design and Construction

George Swanson
Oram Miller
Wayne Federer, Editor

The cover drawing, illustrating the structure of a breathable wall built with Durisol® cement-bonded wood fiber wall forms, is reproduced courtesy of Durisol Building Systems Inc., Hamilton, Ontario.

Disclaimer

The information presented in this manual is intended as a guideline only. Every effort has been made to present this information as accurately as possible as of the time of printing or electronic distribution based upon the experience of the authors, other members of the Building Biology® profession, and the building trade. However, as explained in the Editor's Note on page xviii, because this pre-publication draft version has not been 100% completed by the authors or the editor, nor reviewed by all the experts on our list, we cannot yet vouch for the truthfulness of all contents to the high level to which we aspire.

Competent architects, builders, subcontractors and homeowners are invited to use these protocols, but they must assume full responsibility for their use. Likewise manufacturers must assume full responsibility for the reliability of their products mentioned in this manual.

The authors of the individual protocols, the editor, the contributors and the International Institute for Bau-biologie® and Ecology (IBE) assume no responsibility or legal liability for the use of the protocols or products contained in this manual by builders, developers, architects, subcontractors, or home-owners.

In addition, the information presented in this manual gives general advice on those influences in the built environment that are known to be possible causes of illness. Always consult your health care provider for your individual health care needs and concerns. The information contained in this manual is presented for educational purposes only. It is not intended as a substitute for informed medical advice or care by a health care provider. You should not use this information to diagnose or treat any health problem or illness without consulting your health care provider.

Finally, it is important to note that while this manual is based upon a number of general principles of Building Biology®,[1] it is not an officially sanctioned publication of the International Institute for Bau-biologie® and Ecology. Rather it represents the collective experience as practicing building biologists of the authors and editor and those who have contributed to it, as recognized in the Acknowledgements. Aside from specific courses on the use of building materials presented in this manual, taught by author George Swanson, those wishing to learn how to implement these and other healthy building practices should seek training through the IBE in Clearwater, Florida (www.buildingbiology.net).

[1] See chapter 5, "The Basic Principles of Bau-Biologie."

Inquiries regarding requests to reprint or translate all or part of *Breathing Walls: A Biological Approach to Healthy Building Envelope Design and Construction* should be addressed to the Editor:

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Acknowledgments

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We extend a special thanks to founder and past-president of the Institute, Helmut Ziehe, for bringing this precious knowledge to America in 1987 and for creating and leading the Institute along with his beloved wife, Susannah. The two of you have worked tirelessly these past two decades inspiring us to bring the knowledge of healthy homes to our clients and colleagues throughout North America. You have always focused your efforts on showing us how to help our clients create an environment where they can heal within their homes and offices. Humanity owes a huge debt of gratitude for what you have provided.

The remainder of this Acknowledgments section is organized to be consistent with the structure of the book. First we try to understand the basics, then we choose materials, and finally we build homes.

In the quest for understanding, we are grateful to our international colleagues in Baubiologie and related building professions who provided invaluable insights on what is meant by a "breathing wall." We received input from Germany (Gerhard Brohm, Olaf Erber, Klaus Graeff, Thomas Hagelstein, Marion Hantschmann, Michael Meyer-Olbersleben, Rudolf Prock, Jens Rech, Manuel Reig, Peter Schulze, Klaus Zahn, and Thomas Haumann); Austria (Herbert Gruber and Roland Meingast); Switzerland (Luca Giordano-Bisogno, Urs Maurer, Paul Nijman, and Ernst Sturzenegger); Australia (Michael Meyer); and Canada (Katharina Gustavs). Rupert Schneider and Winfried Schneider of the Institut für Baubiologie und Ökologie Neubeuern (IBN) in Germany also kindly made available to us an updated chapter from the German correspondence course.

We also thank building scientists who weighed in on the latter topic, including John Straube, University of Waterloo and Building Science Consulting, who also gave us permission to reproduce his graphs displayed in chapter 6; Carsten Rode, Technical University of Denmark; and Bart Kramer, student at the Technical University of Delft. Neil May of Natural Building Technologies in the UK graciously provided permission to adapt his tables of material properties for chapter 6 and Gernot Minke of Kassel University in Germany gave us permission to use Figure 10. Additionally we wish to acknowledge the sources we quote in our manual, including Paul Fisette of the University of Massachusetts; Joe Lstiburek, Building Science Consulting; Carl Seville, Seville Consulting; and

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Last but certainly not least, the authors also wish to extend a heartfelt thank you to our significant others for their patience as we spent the countless hours needed to write this manual. Without your support we would not have been able to complete this project.

Preface

Although the term "Building (or Bau-) Biology"® has been used in Europe for over 50 years, it is relatively new in the USA. This aggregate of perennial building wisdom primarily from Europe, Asia and the Middle East was first brought to the USA by Helmut Ziehe, who completed the first translation of the German Baubiologie correspondence course for American audiences and opened the first Building Biology® center in Clearwater, Florida in 1987, now known as the International Institute of Bau-biologie® and Ecology.

At the heart of the Building Biology® philosophy is the time honored concept of the "breathing wall," that is, all natural, self-regulating, electromagnetically balanced materials that have the capacity to diffuse moisture, air and pollutants. These walls can be made using locally available, all natural materials developed over thousands of years of accumulated building practices. The Germans then took this knowledge and put the rock solid scientific data behind why these practices work so well.

The exact opposite of the concept of the "breathing wall" is the modern, "airtight" sealed building envelope so common now in this country with a suffocating airtight polyethylene vapor barrier. Fortunately it is nearly impossible to fully "seal" a building, but the closer a building gets to being airtight, the higher the probability is that the indoor air will be compromised. This combined with the toxic soup that comprises the majority of building materials used in North American has contributed to the widespread phenomenon of "Sick Building Syndrome." It is only in the last several years that the often disastrous effects of this closed, non-breathable, mechanically dependent suffocating system of construction have become apparent.

It has been estimated that in a typical $250,000 new home, a full 90% of the installed materials are in the building "shell" or "envelope." The cost to build this "shell," which includes floors, walls and the roof (and excludes doors, windows and finishes) represents on average less than 20% of the total construction cost of the building. Furthermore, less than half of this amount (about 10%) is for materials, yet this 10% of the construction budget represents 90% of the bulk of the materials of the building![2]

In no other area of construction can more be done to affordably eliminate toxins than to concentrate on this 10% dollar component of your building. Typically you can eliminate nearly all the toxins of this 90% bulk component by spending an additional amount that raises the total cost of construction by only a few

[2] For example, in a 1.5 million dollar home the ratio of raw minimal "shell" materials (minus doors, windows, and finishes) to final cost of construction may be as low as 3-4%, not 10%. High-quality, energy-efficient, nontoxic shell materials rarely cost more than 30-50% over conventional costs, adding only 1-2% to the overall cost of the house while easily doubling its energy efficiency and removing 90% of its toxins.

percent. On the other hand, getting all of the last 10% of the toxins out of your building could easily double its cost!

While attention does need to be paid to these areas, such as finish surfaces, moldings, flooring, cabinets, hardware, draperies, and furniture, in order to create a truly healthy home, it is most cost-effective to concentrate the bulk of your money and efforts on building a natural, breathable building envelope.

Improved indoor air quality through elimination of the poisons in the building envelope is only the beginning of the benefits. Superior longevity, better thermal storage qualities, better effective insulating qualities, improved fire safety, less moisture buildup and superior resistance to mold and mildew are just a few of the added benefits. In fact every recommendation in this manual offers improvement in each area mentioned above.

Building Biology® is a comprehensive and focused body of knowledge that examines the delicate balance between human health and the built environment. Through the International Institute for Bau-biologie® and Ecology, Inc. (IBE), a national network of Building Biology® professionals and training programs has been established in association with an informal worldwide network of Baubiologie centers. The IBE in North America and this worldwide network have a common goal of creating a more holistic, harmonious and sustainable habitat for humans on earth.

It is with a tempered sense of humility that the contributing authors of this manual offer this up to date North American adaptation of the time honored Building Biology® principles for building envelope design and construction as guidelines, and as at least a partial antidote to many unhealthy modern building practices.

TO A HEALTHY AND HARMONIOUS BUILDING EXPERIENCE!

Sincerely:

George Swanson, B. Sci. (Ind. Tech.)
Building Biology® Practitioner
www.geoswan.com

Co-author's Note for Pre-publication Draft 2008-04-30

After four years, we offer this pre-publication draft to those readers who have patiently waited for a written compendium of the protocols practiced by cutting edge builder and building biologist, George Swanson of Austin, Texas. It has been a privilege to put his teachings to paper. This has truly been a collaborative effort, and I want to thank my colleagues, Wayne and George, for expanding my knowledge of the field of healthy building envelopes. We present this draft of our manuscript to you, our readers, for your use and, hopefully, your review and feedback.

Please let us know your thoughts, both positive and critical. We are especially interested in the experiences of builders from around the country. Publication-quality photos would also be helpful, including examples of mold, water intrusion, the effects of common building materials, and any other topics presented that don't yet have photos to accompany them. We would acknowledge you as the provider of the photo(s).

Naturally this is a work in progress and some of the material is outdated before it even gets to the printer. We do, however, welcome the opportunity to present an alternative to the current practice of building, which for many has been a source of ill health. We will continue to update the manual in future versions.

We applaud the efforts of all those courageous builders who are "going green." You will ensure the health of our planet. This work augments that new direction by focusing on the health effects of the built environment on its occupants and ensures that as we preserve the planetary environment, we also preserve the health of ourselves and our families.

Please contact us with your feedback.

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Back in my college days in the 1970's my favorite inorganic chemistry professor had been looking for a textbook for his new class offering on an advanced topic, but none existed. But "Cube" persevered and discovered that a rather famous professor at the university where I would end up going to graduate school was actually in the process of writing one, and this guru would be quite willing to share an early pre-publication draft. So my classmates and I suffered through a semester trying to make heads or tails out of his manuscript.

Well, as if that weren't enough, the very next year my friend Stan and I ended up in the author's own class on the same topic! This time his publisher's galley proofs served as our textbook. The professor turned out to be quite friendly, with a sense of humor to match his rather large ego, and once we knew Russ we kidded him about all the errors we had found the previous year. So when our next exam was imminent he retorted that the book was in much better shape now and he would buy beer for the entire class of thirty in the unlikely event that we could collectively find a certain substantial number of errors before the test. Although never much of a drinker, I sat down with Stan and started listing errors just the two of us had marked on our copies. After less than an hour we had easily exceeded the free beer requirement for the entire class. I thought differently at the time, but looking back on the experience, from the perspective of an editor, I think the wise professor probably got the last laugh on us!

Unfortunately George, Oram and I do *not* have a captive audience of students to challenge our authority, but we *do* hope you will help us out, for we are writing a book that is on people's wish lists, with apparent demand far exceeding what existed for Russ' specialized physical inorganic chemistry text! The authors' discussions with clients and online inquiries received indicate that people are hungry for a healthy new building manual. Our sincerest desire is to get this "tool box" into the hands of aspiring new homeowners, designers and builders everywhere, before even one more "sick" building is constructed. So this editor has reined in his strong perfectionist streak and we take the somewhat unusual step of publicly releasing an incomplete draft.

In the publishing world, "pre-publication" still more often than not refers to a draft of a book that is all but ready for publication and entering the serious promotion phase. These books only need some gushy cover "blurbs" to be composed by people having impressive credentials or name recognition, while simultaneously book reviews are solicited and written by the trade journals and magazine editors to whom the book is circulated at a strategically chosen time.

However in the scholarly world in this electronic age, "pre-publication" has taken on a rather different meaning. Rather than just submit their work to their favorite scientific journal for peer review, resulting in a lengthy wait before colleagues actually see it, researchers are increasingly turning to "preprint servers" to post their work and solicit rapid feedback from their peers prior to submission for publication in a print journal. The journal editorial boards have struggled with this trend and many have (sometimes very reluctantly) altered their long-standing policies forbidding public release of information prior to publication.[3,4]

Our motivation to release this draft now is similar to that of scientists and other researchers who post their research findings online rather than following the traditional publishing model. The good news is that eBooks[5] exhaust virtually no natural resources and can be updated any number of times, offering an affordable means for you to benefit immediately from our knowledge as you design and/or build one or more healthy homes. In the process many of you may give us your valuable feedback to improve the manual before it is published.

As indicated on previous pages this is still a work in progress. Most notably, several whole sections of one chapter (chapter 8) that were less essential are missing. Of course we will remedy these omissions in our updates. Although you can now do unlimited full-text searches of our eBook[5] version, we do intend to add an index and other finishing touches. We acknowledge our manual can still be significantly improved with additional research, writing, illustration (artwork as well as high-quality photos), editing and review by carefully selected experts. Despite my meticulous approach we are still finding errors. Prior to publication we will more thoroughly scrutinize everything and make updates.

Moreover, we are only just beginning to give the book a "soul," having concentrated to date on accurately fleshing out its highly technical content. Our ultimate goal is to create a more user-friendly and visually appealing book for a wider audience than this volume is likely to attract in its present format. For example we contemplate added sidebars with quotations and interesting stories.

During our journey towards final publication we anticipate making later drafts available to you. These will be released in either eBook[5] or spiral-bound format. To learn about updates please stay tuned to the authors' websites, www.geoswan.com and www.createhealthyhomes.com.[6]

Lastly, should you wish to quote or cite this unpublished manuscript in your own publications, kindly abide by the request made in our Copyright Notice (page iv).

Happy reading!

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[3] The topic of preprint servers and how they relate to the publishing process is discussed on the Bioinformatics Zen blog. See posts dated June 21, 2007 to September 10, 2007: http://www.bioinformaticszen.com/tag/pre-publication/.

[4] S. P. Harter and T. K. Park, "Effects of Electronic (Pre-)Publication on Scholarly Journal Publishing: Emerging Manuscript Consideration Policies," *Proceedings of the ASIS Annual Meeting*, vol. 35, p. 438-44 (1998).

[5] We strongly encourage you consider our eBook offering. Not only does it save trees, it also may optionally be updated (see note 6) at no cost to provide you with the latest and most accurate content. Our eBook offers many features not possible in the print version: color photos, full-text searchability, bookmarks to accelerate navigation within the document, and hyperlinks that connect your web browser to online references..

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Part One. INTRODUCTION

We begin this manual with a brief exploration of Building Biology®, the discipline providing the scientific justification for building homes with "breathing walls."

At the outset of Part One (chapter 1) we present a very brief history of twentieth-century construction in North America. This illustrates how, as society abandoned time-honored natural building materials and methods in favor of new technologies that significantly altered the physical characteristics of the structure (notably its "tightness" or "breathability") as well as the chemical composition, residents increasingly experienced significant health problems.

Next we briefly document the origins of "Baubiologie" in Germany in response to similar health challenges followed by the import of and rise of the Building Biology® profession in North America (chapter 2).

As explained in chapter 3, building biologists have much to offer homeowners and the building trade, including education and consultation on how to design and construct a healthy home. This process can be done affordably, with lasting benefits in reduced operational costs as well as high initial and retained market value.

We close our overview of Building Biology® with a discussion of how the profession's emphasis on promoting *healthy*, *bio*compatible technology complements and reinforces the "green building" approach to protecting the environment (chapter 4). We mention just a couple of instances where our recommendations differ from those commonly given by proponents of green building.

Finally, we summarize the twenty-five principles advanced by the founders of Building Biology® to guide the work of practitioners in the field (chapter 5).

Chapter 1. Historical Background

Hi folks, this is George to share a lesson from my formative years. It was 1961. My family was sitting around the kitchen table, reviewing our long-anticipated "modern renovation plans" for our not-so-vintage 1922 lath-and-plaster, asbestos "Bricktex" sided pre-WWI two-story bungalow. Already gone was the rumored original clap-board siding, the "fish-scale"cedar-shingled gable ends, the hand-carved eve brackets and the signature massive sloped front porch posts (replaced by circa 1950) spindly "wrought iron." Also, about one third of the interior cracking lath and plaster had been replaced with (gasp) "DRYWALL."

"DRYWALL!!! – the death of the building" was blurted out three times by the glassy-eyed, old Norwegian senior carpenter who was tearing out old insulation from my bedroom walls. "TRULY THE DEATH OF THE BUILDING" he authoritatively lamented as I watched the last of the old newsprint and horsehair insulation being removed from my room. At all of 11 years old, my only exposure to "DRYWALL" at that time was the stack of it that had landed on our front porch earlier that week, the stuff the old carpenter would call that "DAMN S...T" every time he would walk by. What I did know by the end of the same week was that I was certainly glad that my own room was being re-paneled in knotty pine planks, rather than DRYWALL!!!

What was the perennial, old-world wisdom the old carpenter was trying to communicate to his young, seemingly unappreciative, building associates? What hidden secret did the old-world carpenter have that seems to elude an entire generation of hastily (if at all) trained young apprentices? Was everyone under sixty in 1961 doomed to never know "The Secret"?

The occupants of a typical post-World War I "breathing wall" frame house (see Figure 1) have rarely suffered from modern "sick building syndrome." An entire generation of European old world builders were still around, however by the time the post WWI building boom started, very few of the truly old, old-world construction techniques were in general practice in North America. Even though modern "stick frame" construction had fully replaced "timber frame" and straw-clay infill, a few old-timers still carried on the tradition of using materials that had natural hydration qualities. Board & batten, clapboard or lap wood siding, stone or brick exterior were common. Lath and plaster, with the 2-inch gap between the horizontal 1-2 inch wood strips heavily plastered, was the interior wall finish of choice. Hydronic (steam radiator) heating worked especially well in conjunction with lath & plaster walls' ability to store, distribute and dehumidify itself. Roofs were commonly made of wood shakes, slate or tin. Foundations were typically stone or brick with no modern water-trapping plastic "waterproofing." These combinations achieved a good balance of thermal mass and breathability. Insulation was optional.

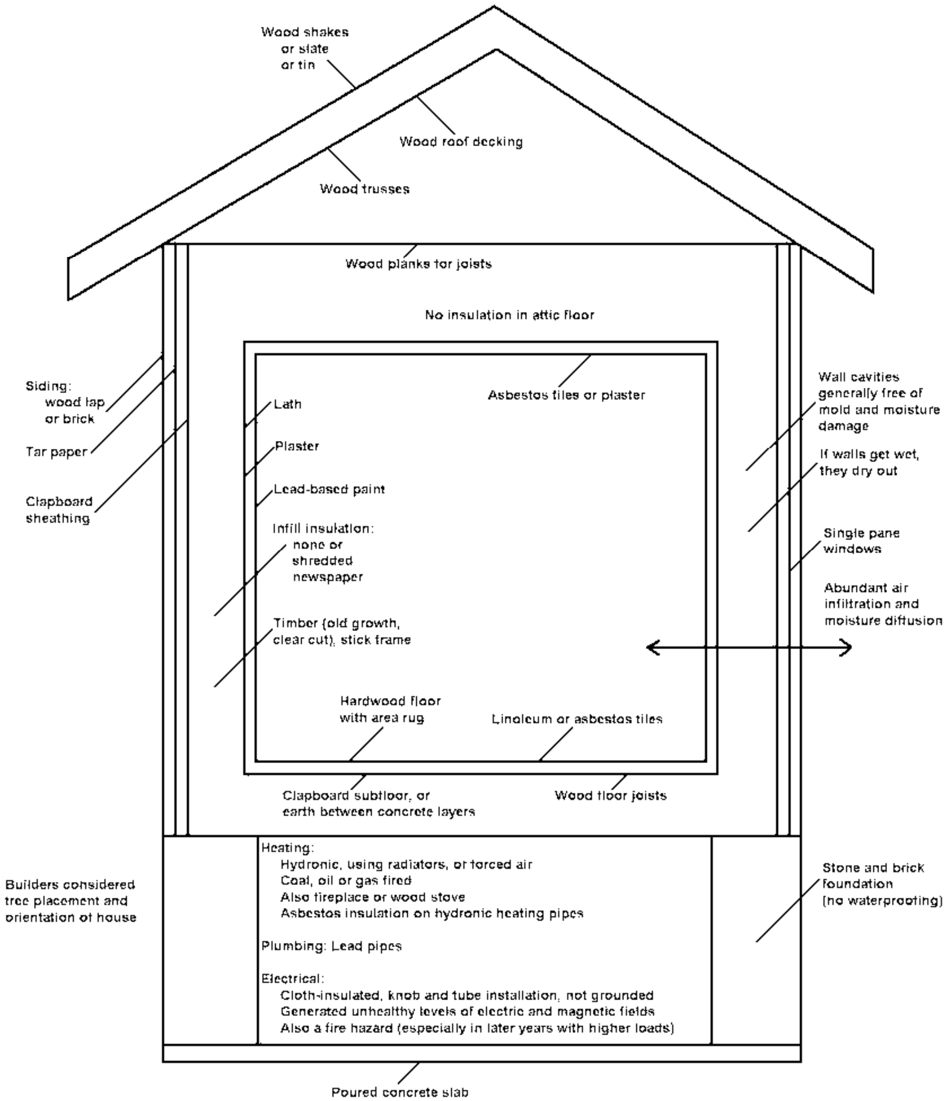

Figure 1. Typical post-World War I frame house (1920s, 1930s, 1940s)

The largest boom in North American housing took place directly after WWII. With the return of the GI's from Europe, the demand for inexpensive, rapidly build "Starter" homes skyrocketed. The typical post-WWII frame house (see Figure 2) had to be built faster and more affordably than at any other time in modern history. Lath and plaster quickly got replaced with "Drywall." The earliest version of drywall, introduced in the late 1940's, emulated many of the characteristics of lath & plaster. Typically it was over an inch thick and had approximately one-inch diameter holes drilled in it at ~12"o/c (a clear remnant from when everyone knew a wall had to "breathe"). Composition asphalt roofing was introduced but luckily was still being installed over breathing wood planks and felt paper. Foundations were now often poured concrete or "CMU" concrete block with semi-permeable tar or asphalt waterproofing. Homes of this vintage still rarely trapped water or moisture behind the walls or roof, as at least the outside wall construction was still "breathable." Also, in this era the insulation generally used was still hygroscopic. Buildings literally started deteriorating en masse with the widespread use of thin drywall (with polymeric additives) combined with non-breathable insulation (fiberglass) and non-breathable exterior sheeting (plywood or OSB). Of course, the final death blow was the ubiquitous "VAPOR BARRIER."

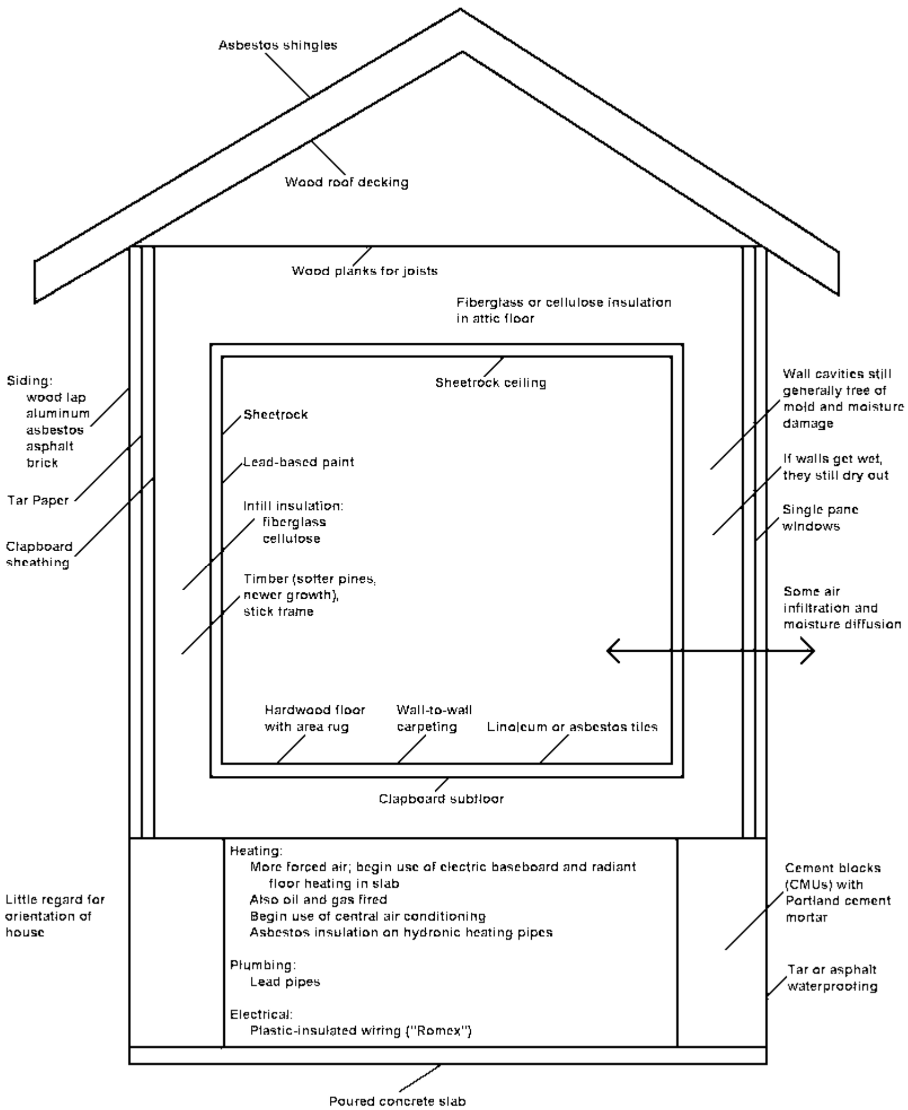

Figure 2. Typical World War II frame house (1950s, 1960s, early 1970s)

The late 1970's saw North America's first "Energy Crisis," that is, the infamous Middle Eastern Oil Embargo. With this late-dawning awareness of the utter finite nature of oil and oil-related energy products came the onslaught of "energy-efficient" building band-aids and conservation technology. (See Figure 3.) Centuries of building wisdom were literally thrown out the door in the pursuit of saving the last BTU of energy – with dire consequences!!! Sealing the building became synonymous with "SICK BUILDING SYNDROME."

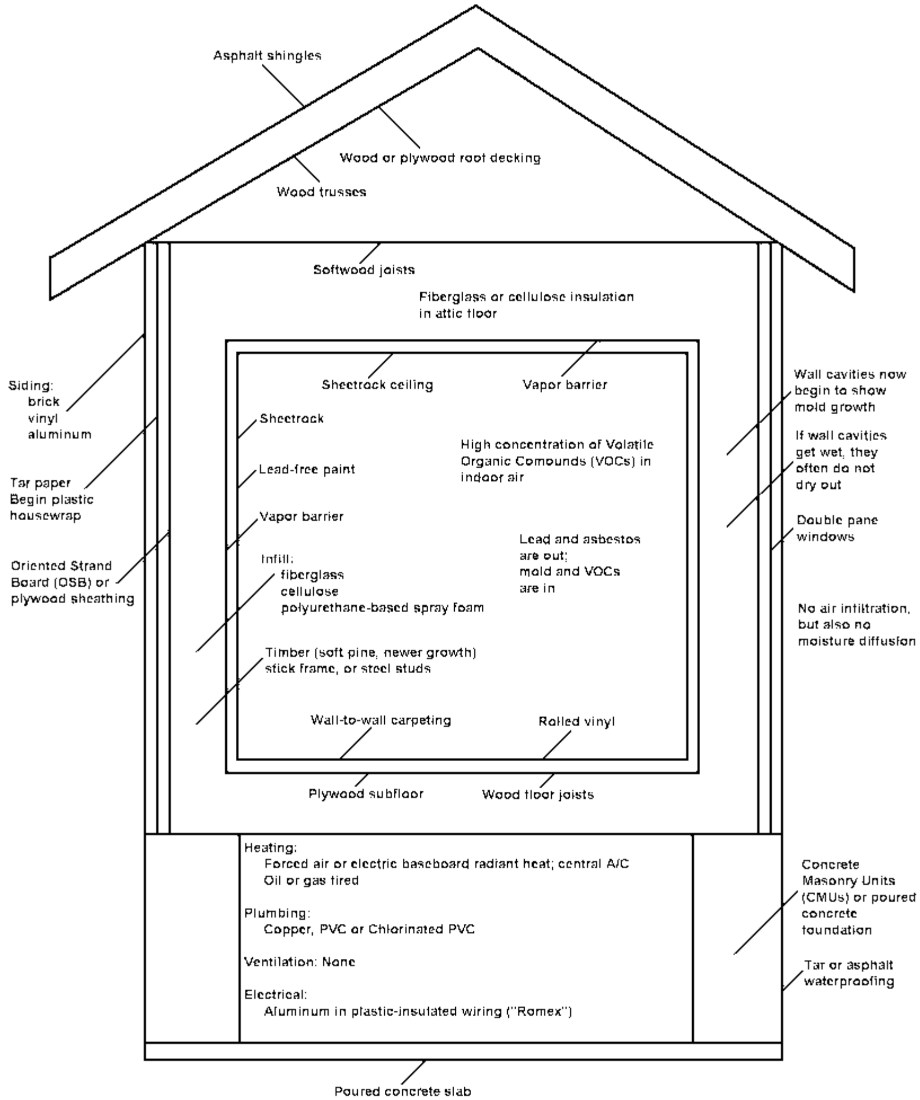

Figure 3. Typical post-oil-embargo frame house (late 1970s, 1980s, early 1990s)

Over the years, as we in the construction industry continued to tighten our building shells, we sealed in more and more of the estimated over 70,000 new chemical formulations introduced since WWII. (It is also estimated that less then one tenth of one percent of these chemicals were ever tested for human safety before being introduced into the American marketplace). Poorly breathing plywood or OSB wall sheeting were now often wrapped in non-breathing polyethylene "vapor barriers" to be finally choked in vinyl or aluminum siding!! (However, as often as not this suffocating polyethylene film was put on the inside of the wall). Slow-diffusing fiberglass insulation became the most common insulation type. Interior walls of this era were now almost exclusively polymer-laden, oxygen-challenged, modified gypsum wallboard (Sheetrock). Roofs were now nearly all poorly breathing plywood or OSB covered with slow-diffusing "composition" shingles. Add to this the widespread use of force-grown (large open cell), fast-growth lumber and a perfect recipe for mold growth was in the making. Even our basements took a hit in the beginnings of the widespread use of unproven, often water-trapping, plastic "waterproofing."

The present day "super-tight" homes (see Figure 4) add significant additional dangers to occupants by often plugging up the last opportunity for natural hydration. In addition to the suffocating features added to many of the 1970's, 1980's and 1990's homes, we've added an onslaught of questionable new ones, including Styrofoam® "out"sulation (covered with plastic stucco that may not be breathable), all plastic ICF's (Insulative Concrete Forms) and Styrofoam®- based SIP's (Structural Insulated Panels).

In retrospect, in reviewing my family's 1961 "modern renovation plans," I can now appreciate how fortunate our family was that we renovated when we did, to be spared the ravages of the whirlwind of trapped toxins, mold cultures and the formidable health risks that have become commonplace in modern construction.

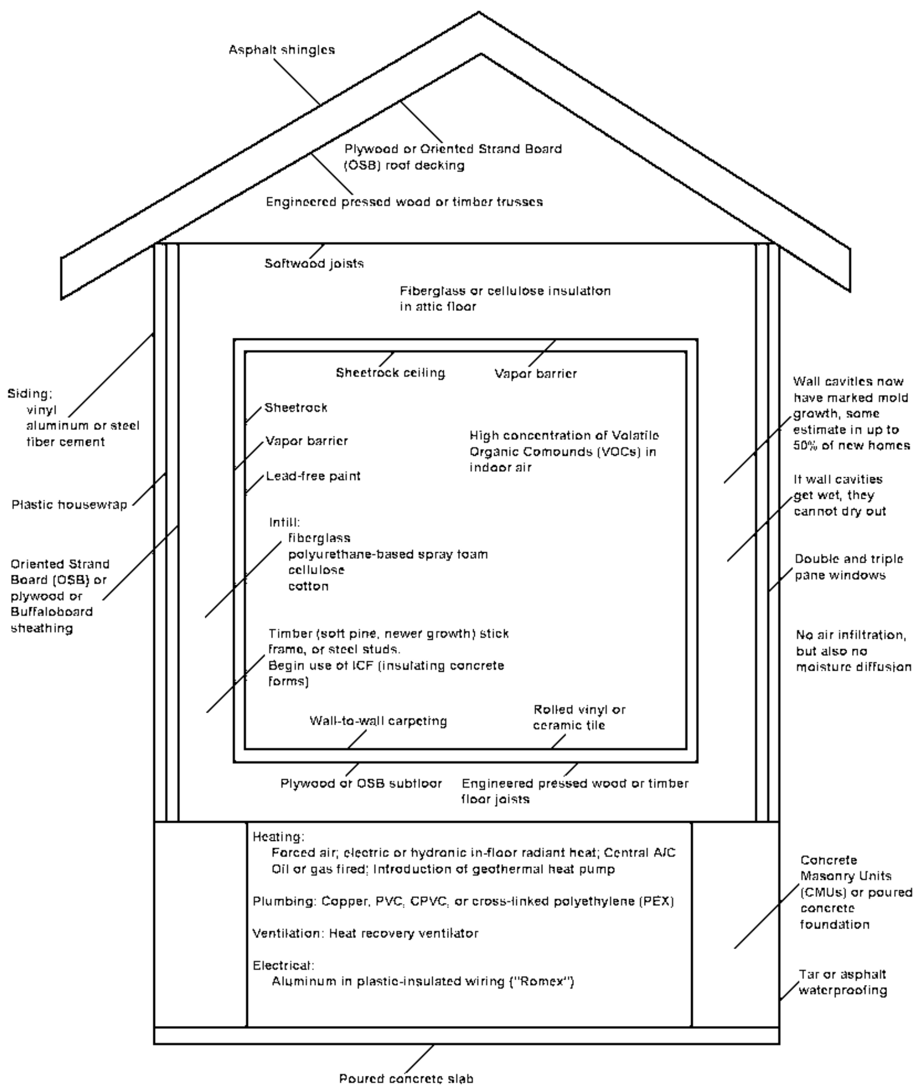

Figure 4. Typical present-day super-tight frame house (since mid-1990s)

Part Two. THE BREATHABLE BUILDING ENVELOPE

A healthy building envelope, consisting of slab, foundation, walls and roof, is the heart of a healthy home. Therefore we devote Part Two to a detailed exploration of this topic.

To understand how a building envelope works, especially an unconventional one such as the so-called "breathing wall" system that building biologists recommend, we begin by providing the necessary scientific background (chapter 6).

Having grasped these concepts, the reader is well equipped to understand the problems associated with water intrusion and how it affects conventional construction. You will learn the ways in which breathable and thermally massive wall systems handle these problems in a completely different way, greatly reducing the ability of mold to grow in walls and foundations (chapter 7).

Next we describe our preferred wall materials that satisfy our design criteria. Practical technologies readily adaptable by the mainstream construction trade in North America are our focus (chapter 8). Cements are integral to several of these systems, so this discussion also addresses the search for healthier alternatives. Finally, we present breathable, thin-wall alternatives to conventional wood-based sheathing, using magnesia, a raw material that is readily available throughout the world. Cavity insulation materials that allow rapid drying of moisture without creating mold are installed into these thin walls.

Now that we have learned how to select our breathable materials and what our choices are, we are ready to begin building! The hands-on aspects of constructing the complete wall system, including all finishing treatments, are explained in chapters 9 and 10 for thermally massive and alternative thin-wall materials, respectively. The remainder of the envelope, consisting of slab, foundation, roof and attic, is presented in chapters 11 to 13. (The detailed construction protocols are saved for Part Two.)

Having finally surrounded ourselves with a breathable envelope, we conclude Part Two by putting forth some additional design considerations necessary for the envelope to function well: moisture control; ventilation; passive solar; windows and doors; heating and cooling (chapter 14). We even discuss how Building Biology® interrelates with such ancient building traditions as China's Feng Shui and India's Sthapatya Veda, also known as Vastu.

Chapter 6. Desired Properties of a Wall System

6.1 Introduction

A wall should not just be an enclosure. It provides far more than just protection from the elements. An appropriately designed and constructed wall is a fundamental part of the home and has far-reaching impact on the health of occupants.

A properly constructed wall should be designed to provide the following benefits:

1. Self-regulation of moisture year round.
2. Storage of heat in winter and cool in summer.
3. Optimally-phased distribution of heat and cool.
4. Radiant heating and cooling.

These benefits are achieved by judicious choice of materials and smart design. Materials should be breathable, allowing what moisture that inevitably does enter a wall cavity to be transported through it in the form of water vapor. Superior thermal performance must not be compromised.

A healthy, ecological wall should ideally incorporate three design elements:

1. Heavy thermal mass towards the inside of the wall
2. Medium core in between
3. Lighter “out”sulation as the outer layer (thicker in northern climates)

From the standpoint of the entire dwelling, the wall and foundation systems recommended in this manual not only possess these characteristics, but they fulfill most of the 25 goals of the Building Biology® profession described in chapter 5 even before additional aspects are considered. This is because the envelope of a house, that is, the floors, walls, and ceiling, is the single greatest component affecting the health of its occupants. If you use the relatively inexpensive mainstream methods of today to build your envelope, then you can expect some degree of “sick building syndrome.” If, on the other hand, you invest in a healthy building envelope as described in this manual, you are well on your way to preventing and avoiding many of the sources of building-induced illness that have plagued home and business owners in modern industrial society for decades.

This chapter will fundamentally cover all of the desirable properties of a wall system: vapor permeability, hygroscopicity, capillarity, thermal mass, “out”sulation, radiant heat transfer, structural integrity, and the subtle energies associated with using natural materials. It is also often desirable to build an envelope that protects the occupants from incoming radio frequencies from outside broadcast sources such as TV, radio, pager, cell phone and wireless Internet (Wi-Fi) antennas. But first we introduce the reader to "breathability," which encompasses the first three of these properties and is of paramount importance.

6.2 What is a "Breathing Wall?"

In the 1850's a professor named Max von Pettenkofer studied the permeability of air and moisture through porous building materials, by blowing out a candle from the opposite side of a wall.[24] One hundred years later the man sometimes referred to as "the father of Building Biology®," a German medical doctor named Hubert Palm, popularized the term breathability (Atmungsfähigkeit).[25] Early building biologists promoted the idea of a "breathing wall."

As properly understood, the "breathing wall" is an extremely important concept for high indoor air quality and mold-free construction. Unfortunately some people (both laypersons and professionals) interpret the expression literally, as if we are saying these walls have lungs. To avoid such confusion this writer puts the term in quotation marks. The terms "breathable" and "breathability" are preferable, as they indicate a passive rather than an active function. Moreover, common parlance (at least in English) uses "breathable" to describe such materials as Gore-Tex®, the porous fabric designed to pass water as vapor but not liquid. Nevertheless, as explained in the remainder of this chapter, breathability in buildings is considerably more complex!

The authors of this manual are among the relatively few American building biologists involved in new construction and the design of building envelopes and therefore they work with the concept of breathability. However to obtain a broader perspective the editor queried two dozen European building biologists, scientists, designers and architects concerning "breathing walls."

These correspondents expressed many different viewpoints on the topic. Our distillation resulted in an appreciation that breathable wall systems actually incorporate several different physical properties that are fundamental to healthy home construction. Building scientists refer to these as *hygrothermal* properties, as all of the related phenomena involve in some way the transport of moisture:

1. Permeability and diffusion
2. Hygroscopic adsorption/desorption
3. Capillary absorption/desorption

Each of the following sections will explain one of the above types of breathability and why it may be essential for a healthy building envelope. We

[24] Max von Pettenkofer, "Sur le comportement de l'air au logement de l'homme" (On the behavior of the air in human abodes), Brusnwick 1877. For a very brief description of this work, see http://de.wikipedia.org/wiki/Atmende_Wand.
[25] Hubert Palm, *das Gesunde Haus* (The Healthy House), Tenth edition, © Ordosan AG; Kösel, Kempten (1992), pp. 84-85. The first edition was published in 1968. *[The date may actually be earlier and we are trying to find out. –Ed.]*

thank Neil May of Natural Building Technologies in the UK for his enlightening online manuscript that rather thoroughly explains these concepts as well as their application. His paper, entitled *Breathability: The Key to Building Performance*, was extremely helpful in writing the next three sections and can be found online.[26]

6.3 Vapor Permeability and Diffusion

Vapor permeability is a property reflecting the rate of movement of water molecules, H_2O, directly *through* a material. It should not be confused with *infiltration*, which is leakage through gaps *between* separate pieces of material. Rather, permeability is determined by the openness of the physical structure *within* the same material, such as wall board, insulation or a vapor barrier. Moisture transport due to permeability is usually small compared to that from infiltration and ventilation, wherein the major water vapor transport mechanism is its movement in flowing air. However, as we shall see below, permeability in the right kind of materials does play a profound role in allowing moisture to escape from building materials before mold formation becomes a problem.

The physical process responsible for vapor permeability of a building envelope is called *diffusion*. Matter is transported spontaneously as a result of the intrinsic kinetic energy and random thermal motion of molecules. Within a gaseous medium such as air the individual molecules mix and redistribute. There is no bulk flow; that is, no net transfer of mass to or from any region of interest.

Diffusion of moisture in air involves movement of water molecules as well as the molecules of oxygen, nitrogen, and minor components such as carbon dioxide. Net diffusion is driven by a gradient of airborne water vapor concentration or H_2O partial pressure. Water molecules dissolved in the vapor phase are spontaneously transported from volumes of higher concentration to those of lower concentration, until the concentration is uniform. This slow process is affected by both temperature and pressure.

The reader will hopefully gain a better understanding by looking at the illustrations in Figure 5 on page 26. In the initial phase of diffusion, the molecules of different gaseous components are far from equilibrium. In the extreme, simplistic case that is illustrated, let us suppose that *all* of the molecules inside the "home" are water vapor (O) and that all of the molecules outside are oxygen (●), just one component of air. (Of course, there is no such thing as an "air" molecule!) As diffusion proceeds (intermediate drawing), water molecules begin to move outside and are replaced by oxygen molecules moving inside. Finally, if and whenever the system reaches equilibrium, all of the molecules are uniformly distributed although still moving randomly.[27]

[26] Neil May's article was last accessed in April 2008, when it was found at http://www.greensteps.co.uk /tmp/assets/1163178050906.pdf.
[27] In the real world we seldom if ever attain equilibrium because the outside humidity, temperature and pressure are continually changing.

Chapter 7. Water Intrusion and Condensation Problems in Conventional, Energy-Efficient Wood Frame Construction

7.1 Introduction

Now that you understand the desired properties of a wall system as we see it, let us examine how well today's building industry fulfills those goals. In the area of water intrusion, the report card is not so good. Valiant attempts have been made to correct the situation with unsatisfying results. In this chapter we provide a detailed review of the problem and end by offering specific solutions using the materials and approaches recommended by our profession.

Practicing building biologists and mold investigators around the country are finding that current wood-frame construction is rife with mold that often affects the health of occupants. Mold grows because walls constructed with plastic vapor retarders (less rigorously known as "vapor barriers") and house wrap with fiberglass as the insulation do not allow moisture trapped within them to fully and easily dry out.

Moisture generally enters modern wall cavities in two ways. The first is direct rainwater intrusion from the outside. The second is leakage of moisture-laden interior air through interior sheeting materials, including plastic barriers. Whichever way moisture enters a wall, once it does so it can cause mold and structural damage, if the wall cavity cannot dry out. The problem is compounded by the use of materials that decompose rather than simply drying out when they become wet. We shall also see that, despite efforts to keep liquid water and water vapor out of walls, plastic house wrap and vapor retarders themselves can fail as moisture barriers.

We take the time to explore this issue for one important reason. Wood frame thin-wall construction is pervasive in this country and so is the idea that a vapor retarder is absolutely necessary. Yet mold is pervasive as well. The problem is that builders still adhere to the notion that the only way to solve the problem is to tighten the house even more in a valiant attempt to keep moisture completely out. Even those pushing to become "greener" try to keep the walls tight. Unfortunately, doing so is simply not possible. The sad reality is that when conventionally built walls fail, they fail in a big way, leaving homeowners sick and financially strapped trying to fix them.

The Building Biology® profession, on the other hand, offers alternatives that stand outside mainstream thinking and are not known by most conventional builders and architects. We join a small but growing subset of builders who recommend wall systems that provide a realistic solution to water intrusion and mold issues while providing thermal performance, durability and increased health for occupants.

Let us first discuss how mold grows and then consider the extent of the problem.

7.2 Mycology

To fully understand water intrusion and condensation and the problems they create, it is helpful to know some basic facts about mold growth. Larry Gust, a Ventura, California building biologist, tells us why the first 24 hours is critical:

1. Fungal growth starts with a small number of dormant spores that are ever present within the indoor environment, having entered over a period of months or years. Some of these spores are viable while others are not.
2. Upon moistening with water, these preexisting spores begin to grow long, branching filaments called *hyphae*.
3. If the fungal life cycle is not interrupted, the hyphae proceed to grow stalks called *conidiophores*.
4. The conidiophores grow and release new *conidiospores*, or "spores," which are capable of renewing the life cycle.
5. Spores produced and ejected are blown away by the indoor air to other locations. (When the environment dries, more spores are ejected.)
6. The fungus is vulnerable at the early stages of germination, when the only things that would be growing beyond the original spore and germ tube (and maybe a couple of mitotic divisions) would be yeasts, which are not harmful to people or pets. These will not survive without continuing moisture.
7. Later on it becomes progressively more difficult to stop further growth because many spores will have grown protective walls. At this point we're on the steep part of the exponential growth curve. This is a dangerous situation for the homeowner.

It is generally accepted that mold needs three ingredients for optimal growth: (1) a bio-film as a food source, present on virtually every surface on earth; (2) moisture; and (3) low air flow. Many experts also include a fourth on this list, darkness, although there are some species that require light to sporulate.

Since the food source cannot realistically be eliminated, mold growth is controlled primarily by keeping materials dry and providing good air circulation. In order to accomplish this without excessive heat loss, thick envelope materials are a wise choice because they possess the capacity to allow drying and slow air circulation through hygroscopic adsorption/desorption, vapor permeability and diffusion, and capillary absorption/desorption, all mechanisms discussed in detail in the preceding chapter. To modern builders this is a novel concept not thought possible, but it is practiced by old-timers in the trade.

As noted above, mold spores can start to germinate within a few hours of the wetting of building materials, whether in a wall or elsewhere in the home. All materials are susceptible, except for sheet metal used in air ducts, upon which it is said mold generally will not grow. (Builders claim, however, that they have building wall and foundation systems that do not trap moisture in the first place. Build walls that allow moisture to dry out within the critical first 24 to 48-hour period while maintaining superior thermal performance. The systems recommended in this manual do just that.

7.3 The extent of the problem

News reports such as a May 13, 2007 article in the Minneapolis Star Tribune[92] entitled, "Water Woes," document the large number of homes that are literally rotting from within because moisture that seeps into walls cannot escape. Most of the homes built throughout the nation in the 1990s used non-breathable materials. Additionally, improper techniques were used in many homes in installing windows, decks and roofs. Structural damage and mold has often been the result, and repairing damaged walls can be quite costly. The article indicated that moisture that had accumulated over years under non-breathable stucco caused substantial structural damage and mold costing homeowners hundreds of thousands of dollars to correct.

Louise Goldberg, an engineer at the University of Minnesota, was quoted in the article as saying, "The fact is, the waterproofing systems in these homes have failed…. If the windows leak or the waterproofing is installed incorrectly, you have a failure condition." She and other experts interviewed for the article stated that the materials chosen did not dry out when water entered due to improper installation. Goldberg also stated that, "Older stucco homes don't have these problems because different construction materials and methods allow them to breathe."

Oak Ridge National Laboratories says:

> If moisture accumulates above a critical material-dependent threshold, the building components begin to rot, corrode, or otherwise degrade in structural or functional integrity. Damage induced by moisture includes rotting of wood studs and other components, corrosion of steel frame members, salt transport, mold growth, and efflorescence. Such damage is related to the inability of the building owner to control moisture within acceptable limits.[93]

Neil Carlson, Industrial Hygienist and mold expert for the University of Minnesota, states that a good percentage of the current building stock will "self-compost" in ten years from mold formation due to improper construction. News reports throughout the country echo these sad statistics. Articles abound with story after story of homeowners moving into expensive new homes, only to have mold develop with no recourse from the builder or insurance carrier to help remedy the situation. The burden to fix the problem falls on the ill homeowner who cannot sell their house and must live in moldy conditions because they often cannot afford to live elsewhere.

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[92] Jackie Crosby, "Water Woes," May 13, 2007, www.startribune.com.
[93] See http://www.ornl.gov/sci/roofs+walls/research/envelope.htm.

Chapter 8. Breathable Envelope Materials

8.1 Introduction

Prior to the Industrial Age, traditional building methods utilized natural materials close to the construction site. Homes were crafted by the owner or by local craftsmen. There was no mass production, indeed there was hardly a building industry. Steve Servais, historian and principal of Pragmatic Construction in Milwaukee, observed that "As shelter is a basic component of survival, one could say that home construction is as old as humanity itself. Often using locally available resources, humans around the globe devised perhaps thousands of unique ways of achieving the same end—providing a barrier between themselves and the outside world of rain, wind, sun, and often enemies. From thatched mud huts to stone villas, a home often reflected the culture of its society, the environment in which it stood, and even the individual personality of its builder."[118]

To satisfy the building biological criteria set forth in chapter 6, our building materials must be permeable, hygroscopic, and have the desired degree of capillarity. We call these characteristics breathability. Moreover the materials should ideally have a high thermal mass and be progressively more insulating towards the outside of the wall, providing what we call "out"sulation. Clearly the structure should be strong and stable enough to bear weight indefinitely. Lastly we prefer walls constructed from primarily natural materials, as they alone provide the full range of desired properties as well as health-promoting subtle energies, without outgassing

Arguably in an ideal world every dwelling would be meticulously hand-crafted with locally available natural materials that satisfy our criteria, with little regard for the cost of labor. In recent years, beginning in the 1960's and 1970's with the back-to-nature movement, there has been a revival of these time-honored building techniques. But what was taken for granted is now considered as "alternative." Therefore these methods tend to be used by mavericks, artisans, and free spirits who build a very small number of homes. Doing it the old-fashioned way may be highly satisfying to builder and owner. Unfortunately the labor-intensive methods and the absence of standardized materials mean that a conventional modern contractor finds it difficult if not impossible to economically build using these age-old techniques. This is changing, however, as more and more builders jump on the "green" and sustainable band wagon, seeking materials to stay competitive in the marketplace, which itself is going green. As you will see, there are several manufacturers who use traditional materials to produce modern building products that satisfy our criteria for health, sustainability and thermal performance.

118 Steve Servais' essay, "A Few Thoughts on the History of Home Construction," was posted on his company's website: http://pragmaticconstruction.com/History.pdf (last accessed November 2007; broken link when checked in April 2008).

With the caveat that there are dozens of books on "natural building" methods whose wisdom we will not try to reproduce or augment, we start this chapter by briefly describing just a few traditional construction materials and techniques, such as earth, straw and clay. We include them because these traditions fulfill all the requirements for a home compatible with Building Biology®. With a lot of effort and determination, a small number of specialists in the industry may find a niche by using these traditional materials. More significant, we think, for the majority of builders and people considering building, is the fact that some of the raw materials have been integrated into the modern composite materials described later in this chapter. Moreover a few entrepreneurs are always working to develop more "practical" technologies based on traditional materials. Therefore we organized this materials-based chapter such that the detailed section on each composite material is preceded by briefer sections on its component raw materials. To some extent we have also taken chronology into consideration in determining when to discuss each material.

For at least 9,000 years *earth* has been used for construction by humans, and it remains one of the most popular building materials in the developing world. Some of the variations are wattle-and-daub, rammed earth, compressed earth blocks, adobe, and cob. Recently, earth-based technologies that can be mechanized and potentially practiced on a wider scale have been developed. *Clay*, a variable fraction but sometimes major component of earth, is a remarkable, finely divided substance that has earned its place as a valuable material with numerous physical and healing properties. Clay is the essential binding ingredient in any earthen building system and is an ingredient in modern composite building materials.

Straw was initially used as in a bird's nest to reinforce earth, improve workability and prevent it from cracking. Much more recently, bales of straw have been stacked to make massive walls. Later in the chapter we will describe advanced building materials made from other plant-based products such as hemp hurds.

Straw-clay construction is a post-World War II improvement on wattle and daub which takes advantage of the insulating properties of straw.

The lion's share of this chapter is devoted to more widely economical methods of construction that are still based upon time-tested traditional building materials, but are made by companies that use modern manufacturing techniques and have a proven track record in the field, backed by industry-accepted structural testing and code approval. We offer them here in the hope that those readers in the building industry will join their colleagues who already use them in this and other countries and will fully embrace them over time. The methods used to build with these materials will be expanded upon later, beginning in chapter 9.

Wood is the first of our recommended materials to be covered and represents a transition from old to practical. Of course log homes were popularized by the American pioneers but they have been around for at least two thousand years. In the last 40 years an industry has risen to manufacture these structures. An alternative but time-tested method is timber frame construction, in which large timbers are used as the major structural support in a post-and-beam configuration. A lesser-known method called cordwood construction is used by some adventurous do-it-yourselfers. Wood chip is also a key component of fiber-cement composites and of “wood wool” panels popular in Europe.

Cement in the form of concrete is a significant component of most modern buildings, primarily as a slab and foundation material. In the middle of the 1800’s Portland cement took over from traditional, magnesium oxide and lime-based cementitious materials. Unlike these traditional cements, Portland cement is *not* a breathable material so the reader will immediately wonder why it belongs in a chapter on breathable envelope materials. For a number of reasons we feel that its inclusion is merited, despite some significant health and global environmental concerns. Portland cement provides the structural skeleton of some breathable composite materials. Portland cement also imparts an alkaline environment to the wall form, disallowing mold to grow. The health concerns pertaining to the use of Portland cement are mitigated by combining it with the right materials. Furthermore, in order to be fully load-bearing, some breathable wall form systems do require structural reinforcement with concrete and rebar.

Autoclaved aerated concrete is a less energy-intensive and breathable Portland cement-based material that has been available for seventy-five years. AAC is made by a unique process that incorporates air bubbles, air being the best insulator, such that the product has a density of only about twenty percent that of ordinary concrete.

Low-density fiber-cement wall form, based on mineralized wood chips and Portland cement, has a proven track record of over half a century and is one of our preferred wall systems. The mineral coating on the wood chips consists of either clay or a ceramic material that neutralizes the sugars naturally present in wood that would otherwise render it incompatible with Portland cement. Generally the stacked wall forms are filled with Portland cement and rebar, allowing buildings to be many stories high.

Traditional or “alternative” cements, in most cases formulated with magnesium oxide and chloride or phosphate-containing minerals, are seeing a renaissance which we fully endorse, for these materials solve the many problems associated with Portland cement. Magnesium oxide, as we will see, was the world’s first cement, and it has seen an explosive revival in recent decades, particularly in Southeast Asia. It is now receiving attention in North America. This chapter describes an impressive array of related building products.

For example, two entrepreneurs in Iowa have revived a formula based on magnesium oxychloride, hemp and rice hulls to create a solid building envelope based upon techniques used for over 600 years in France. Their low-density fiber-cement product is a solid block containing no hollow core and no Portland cement.

Magnesia-based sheeting products have recently become available in North America, following the lead of the Chinese building industry, where over 900 factories now make building boards for domestic use and for export. Plans are underway to have these products made in the U.S. and Mexico for the North American market. In thick-wall construction these products are suitable for floors, walls and ceilings. For homeowners and builders not prepared to use cement-bonded wall forms or AAC to construct massive envelopes, using these sheets to replace drywall and plywood or OSB sheathing makes possible and affordable a breathable, mold-resistant wood-frame structure.

Lastly, we will take a brief look at some well-established breathable building technologies that are only available in Europe or other countries. We are hopeful that these will become available soon in North America.

In fact, many of the materials and methods recommended in this chapter are already in wide use in Europe, where occupants enjoy a significantly higher level of health and comfort than their North American counterparts. We in this country are often trapped in unhealthy and uncomfortable building envelopes, particularly since the widespread introduction of plastic vapor retarders after the oil embargo in 1973.

Part Three. CONSTRUCTION PROTOCOLS

Now that you have a thorough understanding of the science and practical application of breathable walls, we present here in Part Three a condensation of the protocols presented in the previous chapters.

We start with a discussion of steps you can take to minimize the toxicity created in a home as building materials are assembled on the job site. This also safeguards the health of workers (chapter 16).

We then present protocols for each step of the building process, consistent with the sequence generally followed on the job site. We start with protocols for the slab and foundation (chapter 17), with the primary aim to allow for breathability while maintaining thermal performance. We present our recommended protocols for high water tables and radon and other soil gas mitigation. We present alternatives to steel rebar, to eliminate exposure to unwanted electric and magnetic fields. We also discuss ways to avoid mold in crawl spaces. We complete chapter 17 with our recommendations for finishing the inside surfaces of the foundation wall in ways that prevent mold.

The final chapter (chapter 18) contains specific protocols for all above-grade construction discussed in this manual. This includes a reprinting of our summary of the installation steps for low-density fiber-cement wall forms. We also present an alternative protocol, developed by George, for the infill of these wall forms that avoids Portland cement and rockwool inserts for low-rise buildings. We also provide protocols and resources for many of the materials discussed in Part Two, including autoclaved aerated concrete, magnesia-based sheeting and exterior and interior finishes. *[This, and other information in this Part, will be expanded in the published edition. –Ed.]* We also present George's alternative protocol for wood-frame construction, using wood studs, magnesia, clay, borax and infill insulation, either cotton or wet cellulose.

Part Four. CONCLUSION

We have attempted to provide you with a detailed road map to a better outcome than most builders and homeowners have experienced in the past few decades. As you read these pages you likely have come to the realization that, in order to solve the current problem of sick buildings resulting from water intrusion, mold, and our drive to create tight, energy-efficient buildings without compromising indoor air quality, we must borrow from the past to recreate solid, durable, sustainable buildings that keep us healthy and have minimal impact on the environment. Post and beam construction, natural fiber and cement, and thick walls are just some of the techniques our ancestors used that have stood the test of time. As with society's adventures in modern medicine, where we have lost sight of how the body creates wellness, we have likewise strayed into a habit of ever-tightening walls with plastic, creating the very problem we are trying to solve. Alternative approaches in medicine appear new but are in reality a return to traditions abandoned decades ago that had successfully kept civilizations healthy for centuries, if not millennia.

Yes, you will pay more for natural, breathable, massive building materials. But when you choose them, you build a home worth living in for decades that will keep you healthy and that pays for itself over time. You truly get what you pay for.

We have attempted in this manual to stay true to the principles and ideals of our Building Biology® profession, particularly as taught by its founders in Germany and in this country by our Institute's founder, architect Helmut Ziehe. He, his wife, and the early members of our profession have been our guiding light in following the ways of Helmut's native land, where buildings still stand today, centuries after they were first constructed, and the population generally enjoys good health in their homes.

We don't expect all builders and homeowners to adopt our approaches. They are not for everyone. Too much time, attention and money needs to be spent for some in the trade. Yet for those who do take the time and effort to learn what we have to offer and to incorporate these techniques and materials into your plans, you will be richly rewarded with a home that provides good health, durability, comfort and the ability to handle whatever may come with changes in weather patterns and higher energy prices.

We again thank the many individuals who have helped us bring out this knowledge, and welcome your feedback as we endeavor to make this manual more informative and user-friendly for you, our reader.

The best of luck to you.

George Swanson, Oram Miller, and Wayne Federer

About the Contributors

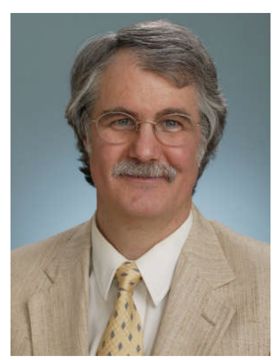
George Swanson received a Bachelor of Science in Industrial Technology from Western Washington University in June 1975. Since that time he has worked throughout the Pacific Northwest, the Great Plains, and the Southeastern United States, designing, building, and managing construction of homes and commercial buildings. His popular *Dome Scrap Book*, inspired by the works of Buckminster Fuller and published in 1981, distills George's experiences designing and participating in building more than 300 geodesic dome structures in the Pacific Northwest from 1974 to 1981.

Since the 1980's George's firm, Swanson Associates, now based in Austin, Texas, has completed nearly one hundred low-toxic and fully nontoxic "breathing" natural building projects in eleven states and several foreign countries. Some of the building systems used were traditional straw-clay, rammed earth, Faswall® cement-bonded wood fiber wall forms, autoclaved aerated concrete block, and most recently magnesia-based (MgO) natural ceramic cement. Several of these projects have included single-family wetland septic systems, rooftop water collection systems, pervious concrete landscape features and solar voltaic energy systems.

George graduated in 1992 from the International Institute for Bau-biologie® and Ecology (IBE) as a Building Biology® Practitioner and was listed in *Who's Who in America* in 1996 for his contributions to Sustainable Technology. Currently he offers natural home and commercial building consulting, design and construction oversee services throughout the states and abroad.

In recent years Swanson Associates have been lead design/build consultants for numerous commercial projects, including several churches, a monastery and a twenty-one-building natural medicine complex in Austin, Texas. Ongoing long-term international projects include a waterfront eco-resort in Kauai, restoration of an ancient hacienda in Mexico, and an eco-village complex in Trinidad. Recently George returned from his fourth trip to China where on an ongoing basis he is conducting product development for DragonBoard®, including all-natural fiber/MgO cement-based wall, roof and floor prefabricated structural insulative panels (SIP's). He is also a partner in the Substance Distributing Company of Austin which distributes several brands of MgO-based building materials.

Since 1975 George has conducted hundreds of seminars across the country and abroad on the benefits of natural building design. He can be contacted at 512-653-8624 or gps@flash.net, or via his website, www.geoswan.com.



Oram Miller is based in Minneapolis, Minnesota where he provides healthy home and office evaluations to clients on site throughout the upper Midwest and nationwide by telephone, fax and email.

Following his education at Colby College (Bachelor of Arts in Biology, 1971) and a 23-year career as a health care practitioner, in December 2003 Oram received his certification as a Building Biology® Environmental Inspector (BBEI) from the International Institute for Bau-biologie® and Ecology. His training included assessment and mitigation of unhealthy electric and magnetic field exposure, indoor air quality, mold, and chemical outgassing.

In addition to helping clients with the latter concerns, Oram consults on the design, building and remodeling of healthy homes and offices in Minnesota and throughout the country. Besides wall and foundation materials as taught by George Swanson, Oram recommends a healthy electrical wiring protocol to create reduced EMF (electromagnetic field) exposure.

Oram writes and lectures on health and the built environment. He has presented to the University of Minnesota, the Minnesota Chapter of the American Institute of Architects (AIA), the National Association of the Remodeling Industry (NARI), the Living Green Expo and the Eco-Experience at the Minnesota State Fair, and the annual conference of the International Institute for Bau-biologie® and Ecology. He has also spoken at numerous healthy living expos and green building meetings.

Oram is active in several organizations dedicated to green construction. These include the Mississippi Headwaters Chapter of the U.S. Green Building Council , the Minnesota Chapter of the American Institute of Architects, and the Minnesota ASHRAE Sustainable Design Committee. He also moderates a monthly study group called the Midwest Building Ecology Coalition.

Lastly, Oram was asked to submit a healthy electrical wiring protocol to the Minnesota GreenStar Program, and he is now a member of their Technical Committee. The protocol is based upon guidelines developed by Oram's colleague and mentor, Spark Burmaster, EE, BBEI of Chaseburg, Wisconsin.

Please contact Oram at Environmental Design and Inspection Services (952-412-0781 or info@createhealthyhomes.com) and visit his website, www.createhealthyhomes.com.

Wayne Federer is based in rural northwestern Wisconsin, on the outskirts of Minnesota's Twin Cites metro area. In 1977 he received Bachelor's and Master's degrees in Chemistry from Bucknell University and went on to the University of Illinois to complete a Ph.D. program in Inorganic Chemistry in 1984.

While still in school, Wayne was inspired to became an environmentalist by his love of the outdoors and his reading of Rachel Carson's *Silent Spring*. However because he has always enjoyed research, Wayne joined the corporate world as a scientist, taking every opportunity he could to foster an environmental ethic. In his 14-year industrial career investigating advanced magnetic and ceramic materials, he gravitated towards projects addressing environmental concerns, including catalytic purification and filtration of indoor air and diesel emissions. In 1989 Wayne was a leader in the organization of a company-wide conference and movement to motivate employees to integrate consideration of environmental concerns into product and process design from the moment of each product's conception. In his community he has advocated for intelligent land-use planning and conservation design of subdivisions.

After striking out on his own, Wayne proceeded to study Building Biology® with the IBE class of 1998. He has attended green building workshops and independently researched many health and environmental issues since then. For this manual, his first foray into the world of editing, he has contributed his scientific and critical thinking skills. The latter are most evident in his writing of chapter 6, for which he gathered input about "breathing walls" from our international colleagues.

Although Wayne's favorite abode is a tent in the wilderness, most of the time he lives in a conventionally-built 1973 rambler. He welcomes your email to editor@breathingwalls.com.

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Breathing Walls: A Biological Approach to Healthy Building Envelope Design and Construction, © 2008 by George P. Swanson, Oram Miller, and Wayne D. Federer, may be ordered directly from the website dedicated to this book, **www.breathingwalls.com**. An alternate route to our secure e-commerce server is via links from the authors' websites, www.geoswan.com and www.createhealthyhomes.com.

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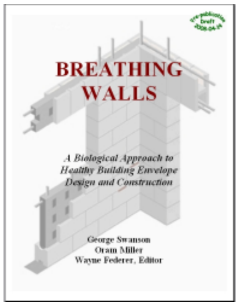
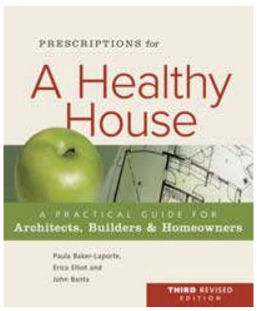
Breathing Walls: A Biological Approach to Healthy Building Envelope Design and Construction
by George Swanson, Oram Miller and Wayne Federer, Editor
Spiral bound and eBook, 304 pages (Pre-publication draft, April 2008); <http://www.breathingwalls.com>



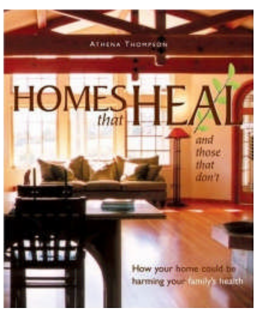
Breathing Walls offers practical alternatives to conventional modern building practices that keep homes airtight. Walls built today are energy-efficient but cannot handle the inevitable intrusion of moisture, resulting in mold, ill health for occupants and structural damage. Healthy, nontoxic alternatives are provided for building walls, foundations, slabs and roofs that allow moisture to dry out before mold can grow while saving energy. Contractor-friendly choices include various thick, "breathable" materials (low-density fiber-cement wall forms or blocks, autoclaved aerated concrete, and wood log) as well as a thin-wall option that employs magnesia-based boards, a material extensively used in Asia. Detailed protocols explain the application of these materials on the job site. Written by building biologists, this is a helpful reference manual for builders, architects and homeowners wanting to build green *and* healthy.

Also Authored by Building Biologists



Prescriptions for A Healthy House, 3rd Edition: A Practical Guide for Architects, Builders & Homeowners by Paula Baker-Laporte, John Banta and Erica Elliot; paperback, 336 pages (New Society Publishers, May 2008); <http://www.newsociety.com/bookid/3997>

"From foundation to rooftop, to home care and repair, *Prescriptions for a Healthy House* takes the mystery out of healthy-house building, renovation and maintenance, by walking the owner/architect/builder team through the entire construction process. Chapters include: Frame construction alternatives, Thermal and moisture control, Finishes, Flooring and Furnishings. Written by an architect, medical doctor and restoration consultant, the book provides a unique guide to creating healthy indoor and outdoor spaces, including many new resources, as well as specialized knowledge from several nationally recognized experts in the field of building biology®."

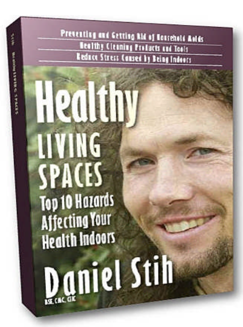


Homes That Heal and Those that Don't: How Your Home Could Be Harming Your Family's Health by Athena Thompson; paperback, 320 pages (New Society Publishers, October 2004); <http://www.homesthatheal.com>

"*Homes that Heal* is a passionate examination of our built environment and the alarming impact today's chemically polluted world is having on our children's health and future generations. Athena explains how our homes influence our health and what we can do about it. The reader is empowered with solutions that reduce the chemical load on all of us while helping create natural, ecologically sound living environments that nurture human health."

Eco Nest - Creating Sustainable Sanctuaries of Clay, Straw, and Timber by Paula Baker-Laporte and Robert Laporte; paperback, 128 pages (Gibbs Smith, Publisher, September 2005); <http://www.econest.com>

"*EcoNest* identifies homes designed and built respectfully, in appreciation of the harmony and beauty of nature and in a way that uses nature's resources so as to consume less energy, create less waste, nurture our health, and enrich our senses. A bird builds its nest using the materials at hand to create a perfect shelter for its bioregion. It doesn't fly to the next state for twigs nor does it build a home that is bigger than it needs. Instinctively it creates an environment that is nurturing, nontoxic, and free of synthetic chemicals. Like the bird, humans desire shelter that is cozy and nurturing, that satisfies the soul, mind, and body. This is the econest."



Healthy Living Spaces – Top 10 Hazards Affecting Your Health by Daniel Stih; paperback, 120 pages (Healthy Living Spaces, June 2007); <http://www.hlspaces.com/HLSBook.htm>

"We may feel it's difficult to create a healthy home. Fortunately, ninety-percent of indoor-health issues can be avoided by focusing on the Top 10. Each item on the Top 10 list is covered in a separate chapter explaining: What is it, what can it do to me, where is it and how do I get rid of it? The first chapter covers all aspects of dealing with mold. The book makes common-sense suggestions for creating a safe, allergy-free environment that include: Getting rid of mold safely and effectively, buying or building a mold-free home, reducing stress caused by indoor toxins, and recommended cleaning products, vacuum cleaners, and air filters."