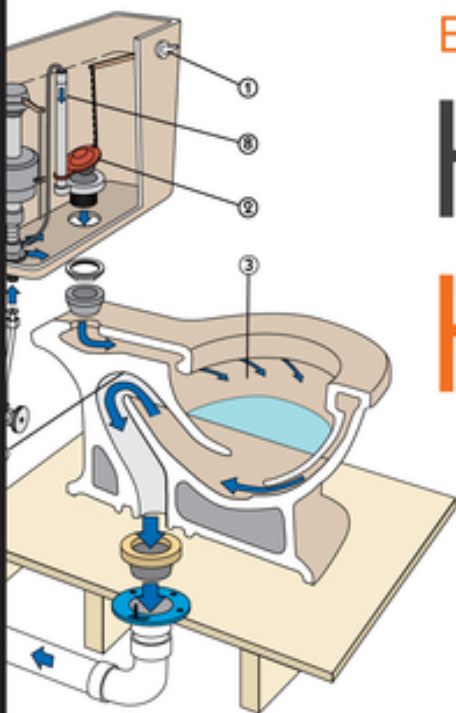


EXPANDED AND UPDATED THIRD EDITION

# HOW YOUR HOUSE WORKS

A Visual Guide to Understanding and  
Maintaining Your Home

CHARLIE WING



**RSMeans**  
FROM THE GORDIAN GROUP®

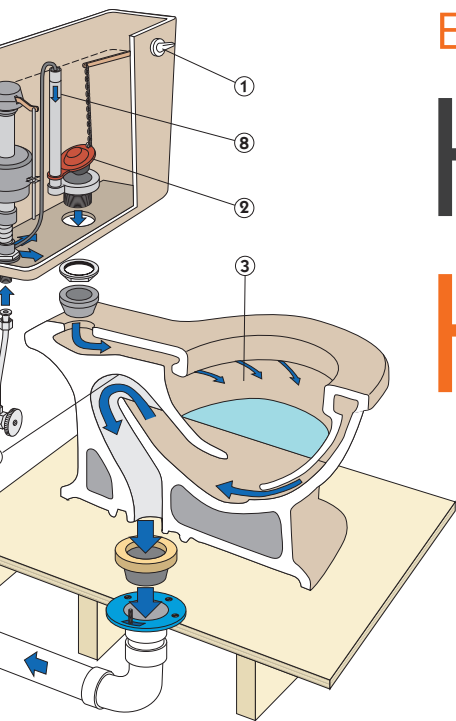
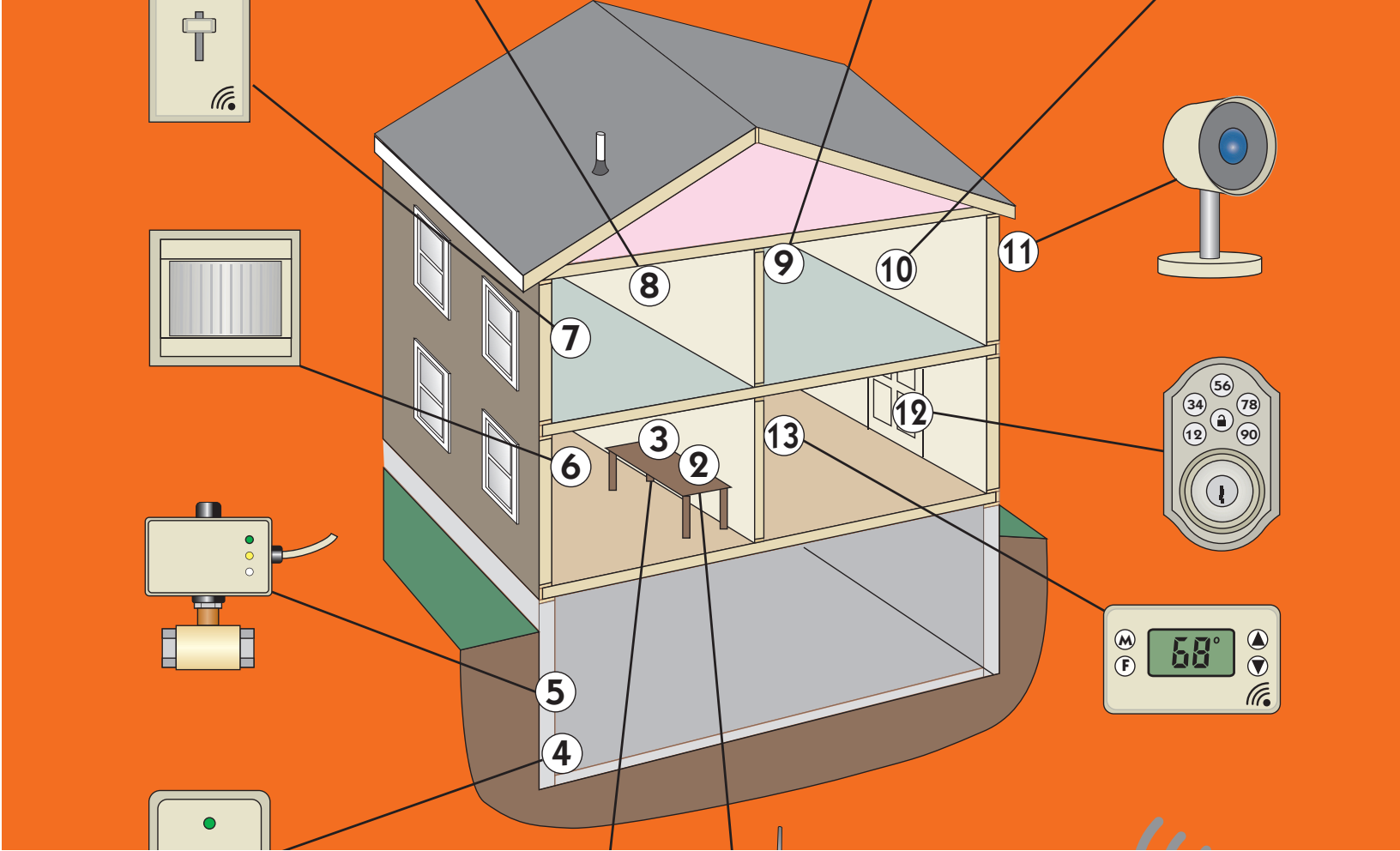
**WILEY**



EXPANDED AND UPDATED THIRD EDITION

# HOW YOUR HOUSE WORKS

. . . *for Wid*



EXPANDED AND UPDATED THIRD EDITION

# HOW YOUR HOUSE WORKS

A Visual Guide to Understanding and  
Maintaining Your Home

CHARLIE WING

Cover Illustrations: © Courtesy of Charlie Wing  
Cover design: Wiley

This book is printed on acid-free paper

Copyright © 2018 by Charlie Wing. All rights reserved

Published by John Wiley & Sons, Inc., Hoboken, New Jersey  
Published simultaneously in Canada

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning, or otherwise, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 646-8600, or on the web at [www.copyright.com](http://www.copyright.com). Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, (201) 748-6011, fax (201) 748-6008, or online at [www.wiley.com/go/permissions](http://www.wiley.com/go/permissions).

**Limit of Liability/Disclaimer of Warranty:** While the publisher and author have used their best efforts in preparing this book, they make no representations or warranties with the respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives or written sales materials. The advice and strategies contained herein may not be suitable for your situation. You should consult with a professional where appropriate. Neither the publisher nor the author shall be liable for damages arising herefrom.

For general information about our other products and services, please contact our Customer Care Department within the United States at (800) 762-2974, outside the United States at (317) 572-3993 or fax (317) 572-4002.

Wiley publishes in a variety of print and electronic formats and by print-on-demand. Some material included with standard print versions of this book may not be included in e-books or in print-on-demand. If this book refers to media such as a CD or DVD that is not included in the version you purchased, you may download this material at <http://booksupport.wiley.com>. For more information about Wiley products, visit [www.wiley.com](http://www.wiley.com).

Library of Congress Cataloging-in-Publication Data:

Names: Wing, Charles, 1939- author.

Title: How your house works : a visual guide to understanding and maintaining your home / Charlie Wing.

Description: Expanded and updated third edition. | Hoboken, New Jersey : Wiley, [2018] | Includes index. |

Identifiers: LCCN 2018008701 (print) | LCCN 2018012069 (ebook) | ISBN 9781119473480 (pdf) | ISBN 9781119473527 (epub) | ISBN 9781119467618 (pbk. : acid-free paper)

Subjects: LCSH: Dwellings—Maintenance and repair. | Buildings—Mechanical equipment.

Classification: LCC TH4817 (ebook) | LCC TH4817 .W56 2018 (print) | DDC 643/.7—dc23

LC record available at <https://lcn.loc.gov/2018008701>

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

# CONTENTS

---

<b>Introduction</b>	<b>xi</b>
<b>About the Author</b>	<b>xiii</b>
<b>A Note from the Author</b>	<b>xv</b>
<b>Chapter 1. Plumbing</b>	<b>1</b>
The Supply System	2
The Waste System	4
The Vent System	6
Private Septic System	8
Lavatory Pop-up Drain	10
Sink Drain	11
Plunger-Type Tub Drain	12
Pop-up Tub Drain	13
Older Gravity Flow Toilet	14
Water-Saving Toilet	16
Traps & Vents	18
Ball-Type Faucet	20
Cartridge-Type Faucet	21
Disk-Type Faucet	22
Compression-Type Faucet	23
Tempering Valve	24
Tub/Shower Control	25
Hose Bibbs	26
Pitcher (Hand) Pump	27
Jet Pump	28
Submersible Pump	30
Sump Pump	32
Pressure Tank	33
Electric Water Heater	34
Gas Water Heater	35

---

---

Electric Tankless Heater	36
Gas Tankless Heater	37
BoilerMate™ Water Heater	38
Charcoal Cartridge Filter	39
Tank Filter	40
Reverse Osmosis Filter	41
Water Softener	42
UV Purifier	44
Fire Sprinkler	45
<b>Chapter 2. Wiring</b>	<b>47</b>
Electrical Circuit	48
Ohm's Law	49
Using a Test Meter	50
120 & 240 VAC	52
Circuit Breakers & Fuses	53
Service Drop	54
Electromechanical Meter	55
Smart Meter	56
Circuit Grounding	57
Electrical Panels	58
Receptacle	60
GFCI	62
AFCI	63
Single-Pole Switch	64
3- & 4-Way Switches	66
Ceiling Fan/Light Switch	68
Dimmer Switch	70
Motion-Activated Switch	72
Flush-Mount Light Fixture	74



---

---

Hanging Ceiling Fixture	75
Floor & Table Lamps	76
Fluorescent Lamps	77
Compact Fluorescent Lamp	78
LED Lamp	79
CO Detector	80
Battery Smoke Detector	81
Wired Smoke Detectors	82
The Smart Home	84

<b>Chapter 3. Heating</b>	<b>87</b>
Gas Warm Air Furnace	88
Gas Hot Water Boiler	89
Oil Warm Air Furnace	90
Oil Hot Water Boiler	91
Oil Burner	92
Fuel Oil Filter	93
Air-Source Heat Pump	94
Ground-Source Heat Pump	96
Ventless Gas Heater	98
Direct-Vent Gas Heater	100
Direct-Vent Gas Fireplace	101
Pellet Stove	102
Air-Tight Wood Stove	104
Electric Baseboard	105
Hydronic Distribution	106
Warm Air Distribution	107
Hot Water Radiant Heat	108
Bimetallic Thermostat	109
Digital Clock Thermostat	110

---

---

<b>Chapter 4. Cooling</b>	<b>111</b>
Natural Ventilation	112
Ceiling Fan	113
Whole-House Fan	114
Window Air Conditioner	115
Central Air Conditioner	116
Ductless Air Conditioner	117
Evaporative Cooler	118
 <b>Chapter 5. Air Quality</b>	 <b>119</b>
Moisture & Mold	120
Humidifier	122
Dehumidifier	123
Furnace Filter	124
Electronic Air Cleaner	125
Air-to-Air Heat Exchanger	126
 <b>Chapter 6. Appliances</b>	 <b>127</b>
Dishwasher	128
Front-Loading Washer	130
Top-Loading Washer	132
Electric Dryer	134
Gas Dryer	135
Electric Range/Oven	136
Gas Range/Oven	138
Coffee Makers	140
Microwave Oven	142
Garbage Disposer	143
Refrigerator/Freezer	144

---

---

Icemaker	146
Trash Compactor	147
Vacuum Cleaners	148
<b>Chapter 7. Windows &amp; Doors</b>	<b>151</b>
Double-Hung Window	152
Low-E Windows	154
Window Insulating Panel	156
Cylinder Lock	158
Deadbolt & Keyed Knob	159
Garage Door Opener	160
<b>Chapter 8. Foundation &amp; Frame</b>	<b>161</b>
Footing	162
Drainage	163
Radon Abatement	164
Slab Foundation	165
Crawl Space Foundation	166
Grade Beam Foundation	167
Full Foundation	168
Pier Foundation	169
Forces on the Frame	170
Beams in Bending	172
Framing Members	174
Post & Beam Frame	176
Plank & Beam Frame	177
Balloon Frame	178
Platform Frame	179
Advanced (OVE) Frame	180

---

---

<b>Chapter 9. Outdoor Equipment</b>	<b>181</b>
4-Cycle Gasoline Engine	182
2-Cycle Gasoline Engine	184
Gasoline Chain Saw	186
Gasoline Lawn Mower	188
Gasoline String Trimmer	190
Gasoline Leaf Blower	191
Cordless Equipment	192
Lithium-ion Batteries	194
Pool Pump & Filter	195
Lawn Sprinkler System	196
 <b>Chapter 10. The Solar Home</b>	 <b>199</b>
Passive Solar Heating	200
Solar Pool Heater	202
Solar Water Heater	203
Photovoltaic (PV) Power	204
 <b>A Homeowner's Tool Bag</b>	 <b>209</b>
 <b>Index</b>	 <b>215</b>

# INTRODUCTION

---

This book offers a unique approach to home improvement, maintenance, and repair. It describes how virtually everything in a house is put together, and how each item functions – from plumbing to electrical, heating and air conditioning, appliances, doors and windows, and even the home’s foundation and wood framing.

The key to the book is the easy-to-understand, see-through drawings. Each one is backed up by clear, brief explanations from a nationally known home improvement expert. It’s a formula for a quick understanding of what you’re dealing with when troubleshooting a problem, talking to your repairman, or planning your new home, addition, or remodeling project, and selecting new fixtures, appliances, or materials.

The illustrations show how the components of a system fit together and how each item is intended to function – whether it’s an air conditioner, a hot water heater, the foundation, or a faucet. The author breaks down the workings of all of the plumbing, electrical, and heating/air conditioning systems, and other house parts, and shows not only what the parts look like and how they interact, but the sequence in which things work. Even complex systems are explained in simple terms and diagrams.

Throughout the book, you’ll also see “Before Calling for Help” boxes – guidance on simple things to check, in many cases solving the problem quickly and inexpensively without having to hire a repairman. If you do find that you need a contractor or serviceman, the book will help you understand your options and be better informed about having the correct elements installed or replaced.

---

---

Maintenance tips and other helpful guidance throughout the book will help you keep your home running smoothly.

Not only homeowners, but handymen and contractors will benefit from the easy-to-interpret information presented here, especially for getting up to speed on items that are not their specialty.

If you would like the confidence of knowing more about how your house works and what to do if something breaks down, read this book. It just may change your life.

**Note:** *This book is intended to provide useful information for understanding the systems, fixtures, and appliances in a house, but it is not a substitute for professional construction, engineering, or repair evaluations, recommendations, or services. Readers should obtain assistance from appropriate experts, as needed.*

# ABOUT THE AUTHOR

---

Charlie Wing is a nationally recognized home improvement/repair expert. He has written or co-written more than 20 books on these topics, including Home Depot's *Decorative Painting, Tiling, and Plumbing 1-2-3* books, *Better Homes & Gardens' Complete Guide to Home Repair*, Taunton Press's *The Visual Handbook of Building and Remodeling*, Reader's Digest's *The Big Book of Small Household Repairs*, and many others, including *Ortho's Home Improvement Encyclopedia* and *How to Build Additions*.

An MIT PhD, Charlie has been a guest more than 400 times on home improvement radio and television shows, including on the Discovery Channel, PBS, and NBC's *Today Show*. He developed and hosted a national PBS series on home remodeling for energy efficiency. He was founding and technical editor for *Smart Homeowner* magazine from 2001 to 2004.





# A NOTE FROM THE AUTHOR

---

After observing neighbors, friends, and family through decades of home ownership, I'm convinced most live in a perpetual state of anxiety. The log cabin with a privy, a fireplace, and a bucket for hauling water has been replaced by homes with sophisticated wiring, plumbing, and appliances. What happens if something goes wrong?

No wonder we live in fear. While school has taught us mathematics, foreign languages, and computer sciences, most of us have no idea how our furnace, refrigerator, or even kitchen faucet works. This is an expensive omission in our educations. In metropolitan areas, the minimum charge for a repairperson to come to your home is about \$150. In fact, repair services are now so expensive that the leading consumer magazine recommends replacing, rather than repairing, most appliances over five years old.

Why don't more people attempt simple repairs themselves? Because they're convinced only professional tradespeople have the special tools and technical knowledge. The truth, however, is the opposite. Let me tell you my favorite home repair story.

A few years back, I was visiting a friend who happened to own a very successful plumbing repair service in a large metropolitan area. His considerable success was built on the promise that a repair would be accomplished the same day, or the repair would be free. He had built a fleet of 75 trucks staffed by licensed plumbers on that simple promise. The promise also allowed him to charge a minimum of \$150 just for showing up.

During my visit, my friend's nearly new dishwasher began making a strange whirring sound. Convinced that the sound indicated an impending complete breakdown, he called the repair center listed for the brand.

---

---

A day later the doorbell rang, and there appeared an appliance repairman with an intimidating tool belt and service manual the size of the New York City phone book. Before starting repairs, he informed my friend he would have to sign a work order agreeing to a minimum charge of \$150, regardless of the problem or the success of the work.

That agreed to, my friend said, “The dishwasher makes a weird whizzing sound, like the motor bearings are gone.”

The repairman plucked a simple Phillips screwdriver from his tool belt and unscrewed the perforated cover of the dishwasher’s drain. Here’s your culprit,” he beamed. He replaced the drain cover and turned on the machine. The noise had disappeared. “That will be \$150,” the serviceman said.

Now what enabled the serviceman to go so directly to the problem? First, he understood how a dishwasher worked—that, for example, it had a drain and a pump impeller to circulate water. Second, he knew from experience that well over half of all appliance “repairs” involve tightening a loose connection, adjusting a screw or knob, or removing a foreign object.

When you go to a doctor with a complaint, the result is most often the same. He or she knows what is inside you and how your different parts relate. Most often the prescription is, “Go to bed, stay warm, and drink lots of water,” not, “I think we need to replace your heart.”

Two principles: that repair requires understanding how things work, and that many repairs are very simple, are what led me to create this book. I have purposely limited troubleshooting guidance (“Before Calling for Help”) to the simplest steps. Those wishing to tackle more complex repairs should:

- 1) Download the manufacturer’s online *Owner’s Manual*.
- 2) Search *YouTube* online for videos of specific repairs.
- 3) Find and order replacement parts on *repairclinic.com*.

# 1

# PLUMBING

---

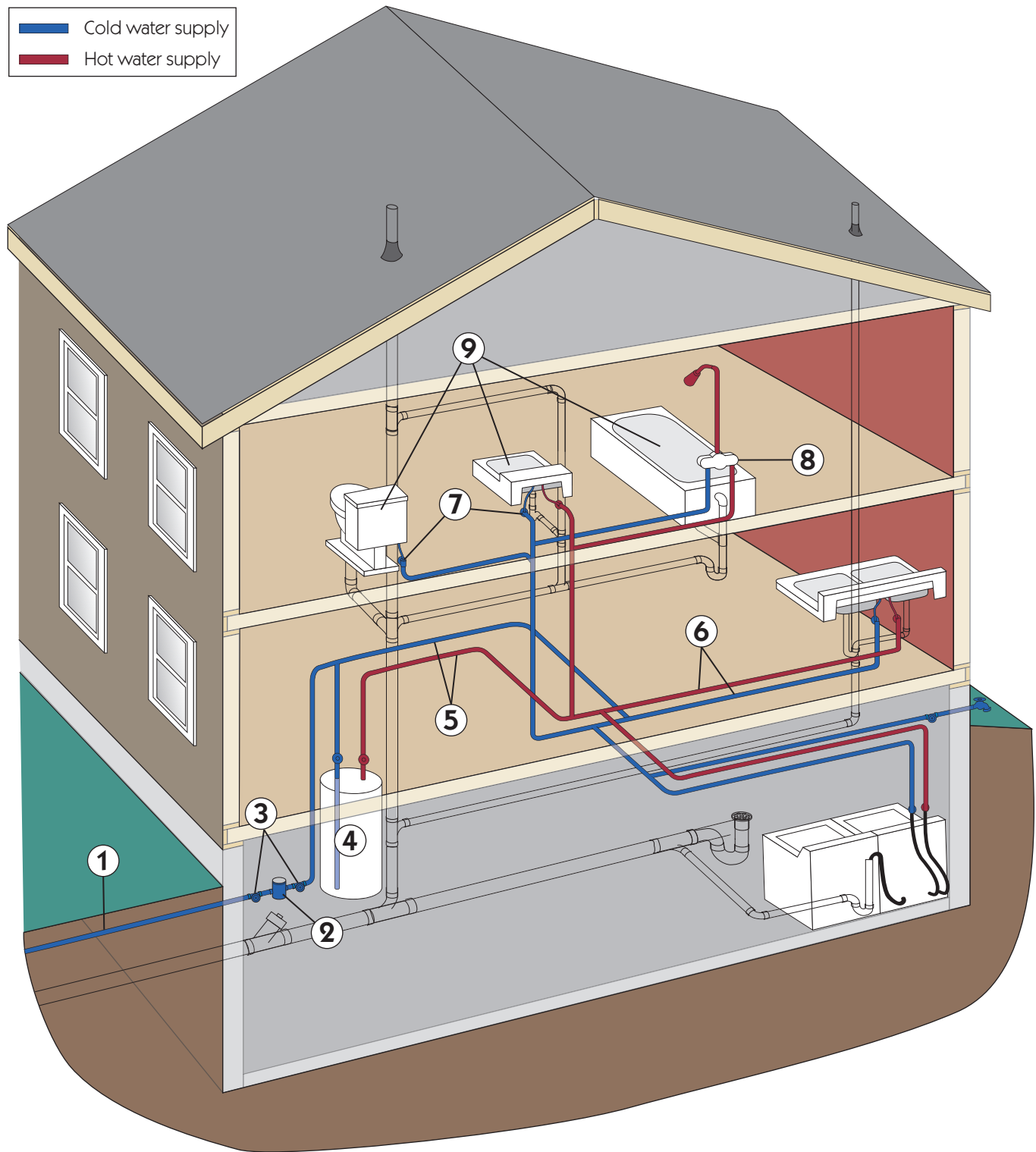
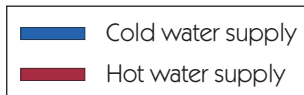
If you are like most homeowners, the maze of hot and cold supply pipes and waste pipes in your basement resembles nothing more meaningful than a plate of spaghetti. This chapter will show you that, in fact, your house contains three separate systems of pipes, all making perfect sense.

Understanding their purpose and how each one works will enable you to decide which projects are in the realm of a homeowner, and which ones require a plumber. If you're planning to build a new home or do major remodeling, this chapter will also help you to visualize the plumbing requirements, and how they'll fit into your space.

A visit to the plumbing aisle of your local home center will show you that do-it-yourself plumbing repair has never been easier. There you will find kits, including illustrated instructions, for just about every common repair project.

Plumbing is not dangerous, unless you're dealing with gas pipes. In fact, call a licensed professional if your repair or installation involves any change to existing gas piping. But plumbing mistakes can be damaging to the finishes and contents of your home, just by getting them wet. The force and weight of water are also something to be reckoned with, if many gallons flow where they should not. Before starting a project involving the supply system, locate the shut-off valve for the fixture you're working on. If you can't find one, shut off the main valve where the supply enters the house.

# The Supply System



# How It Works

The supply system is the network of pipes that delivers hot and cold potable water under pressure throughout the house.

**1.** Water enters underground from the street through a  $\frac{3}{4}$ " or 1" metal pipe. In houses built prior to 1950, the metal is usually galvanized steel; after 1950, copper. In the case of a private water supply, the pipe is usually polyethylene.

**2.** If you pay for water and sewage, your home's usage is measured and recorded as the water passes through a water meter. If you find no meter inside the house, one is probably located in a pit between the house and the street. You can monitor your consumption, measured in cubic feet, by lifting the cap and reading the meter.

**3.** Next to the water meter (before, after, or both), you will find a valve, which allows shutting off the water supply, both cold and hot, to the entire house. If you have never noted this valve, do so now. When a pipe or fixture springs a leak, you don't want to waste time searching for it.

**4.** Water heaters are most often large, insulated, vertical tanks containing from 40 to 120 gallons. Cold water enters the tank from a pipe extending nearly to the tank bottom. Electric elements, a gas burner, or an oil burner heat the water to a pre-set temperature. When hot water is drawn from the top, cold water flows in at the bottom to replace it.

If the home is heated hydronically (with circulating water), the water heater may consist of a heat-exchange coil inside the boiler, or it may be a separate tank (BoilerMate™) heated with water from the boiler through a heat exchange coil.

Wall-mounted tankless water heaters provide a limited, but continuous, supply of hot water through a coil heated directly by gas or electricity.

**5.** Supply pipes—both cold and hot—that serve many fixtures are called "trunk lines," and are usually  $\frac{3}{4}$ " in diameter. Pipes serving hose bibbs and other fixtures with high demands may be  $\frac{3}{4}$ " as well.

**6.** Pipes serving only one or two fixtures are called "branch lines." Because they carry less water, they are often reduced in size to  $\frac{1}{2}$ " and, in the case of toilets,  $\frac{3}{8}$ ". Exceptions are pipes serving both a shower and another fixture.

**7.** Every fixture should have shutoff valves on both hot and cold incoming supplies. This is so that repairing the single fixture doesn't require shutting off the entire house supply at the meter valve.

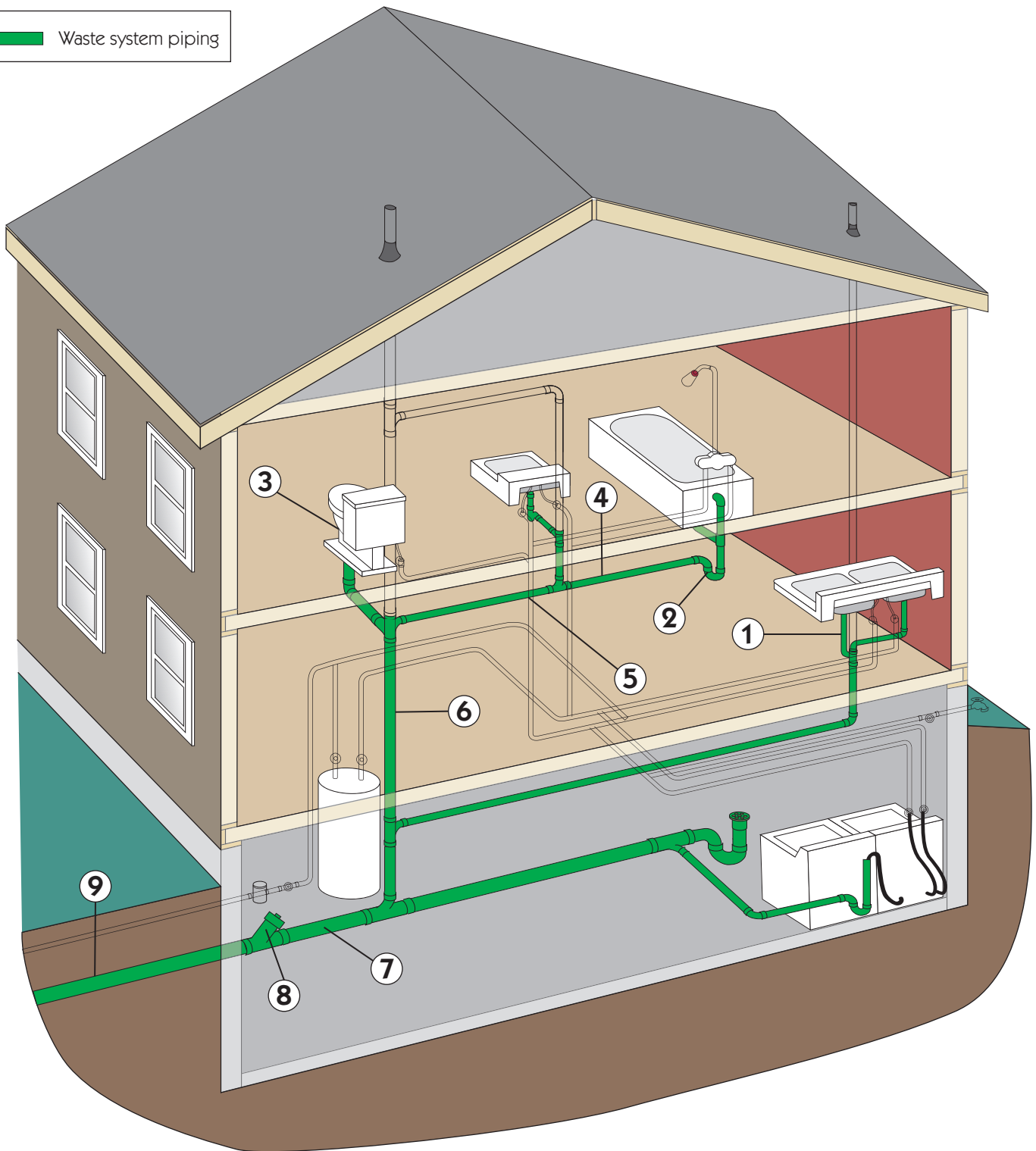
**8.** A pressure-balanced anti-scald valve or thermostatic temperature control valve prevents the hot and cold temperature shocks we have all experienced when someone suddenly draws water from a nearby fixture. They are not inexpensive, but they provide insurance against scalds and cold-water shocks, which may trigger a fall in the elderly.

**9.** "Fixture" is the generic plumbing term for any fixed device that uses water.

Drain pipes are sized according to the rate of flow they may have to carry. One fixture unit (FU) is defined as a discharge rate of one cubic foot of water per minute. Plumbing codes assign bathroom sinks (lavatories) 1 FU, kitchen sinks 2 FU, and toilets (water closets) 4 FU.

# The Waste System

Waste system piping





# How It Works

The waste system is the assemblage of pipes that collects and delivers waste (used) water to either the municipal or private sewage system.

**1.** The pipe that drains away a fixture's waste water is its drain. The minimum diameter of the drain is specified by code and is determined by the rate of discharge of the fixture.

**2.** Each and every fixture drain must be "trapped." A trap is a section of pipe that passes waste water, but retains enough water to block the passage of noxious sewer gases from the sewage system into the living spaces of the house.

**3.** Toilets (water closets) have no visible trap, but one is actually there, built into the base of the toilet.

**4.** The horizontal section of drain pipe between the outlet of a trap and the first point of the drain pipe that is supplied with outdoor air is called the "trap arm." The plumbing code limits the length of the trap arm in order to prevent siphon action from emptying the trap. The allowed length is a function of pipe diameter.

**5.** As with a river, the smaller tributary drain pipes that feed into the main "house drain" are called "branches."

**6.** The largest vertical drain pipe, extending from the lowest point through the roof, and to which the smaller horizontal branch drains connect, is called the "soil stack." The term "soil" implies that the drain serves human waste. If it does carry human waste, and/or if it serves enough fixture units, it must be at least 3 inches in diameter. In a very horizontally extended house, there may be more than one soil stack.

**7.** The largest, bottom-most horizontal waste pipe is the "house drain." In a delicate balance between too-slow and too-rapid flow of waste, the house drain (and all other horizontal waste pipes) must be uniformly inclined at between  $\frac{1}{8}$ " and  $\frac{1}{4}$ " per foot. In a basement or crawl space, the house drain is usually exposed. With a slab-on-grade foundation, the house drain is beneath the slab.

**8.** To facilitate unclogging of drain pipes, Y-shaped "cleanouts" are provided. At a minimum, there will be a 4" diameter cleanout at the point where the house drain exits the building. This cleanout is utilized when tree roots invade the exterior drains and special drain-reaming equipment must be called in to cut the roots. Additional cleanouts are required throughout the waste system for every 100' of horizontal run and every cumulative change of direction of 135 degrees.

**9.** Waste pipe outside of the building line is termed the "house sewer." It is always at least 4" in diameter.