Adrian Smith, the architect who designed the Burj Khalifa, was inspired by the hymenocallis flower. Search the Internet to find out what this flower looks like. What features of the flower provided inspiration?

CHAPTER 7

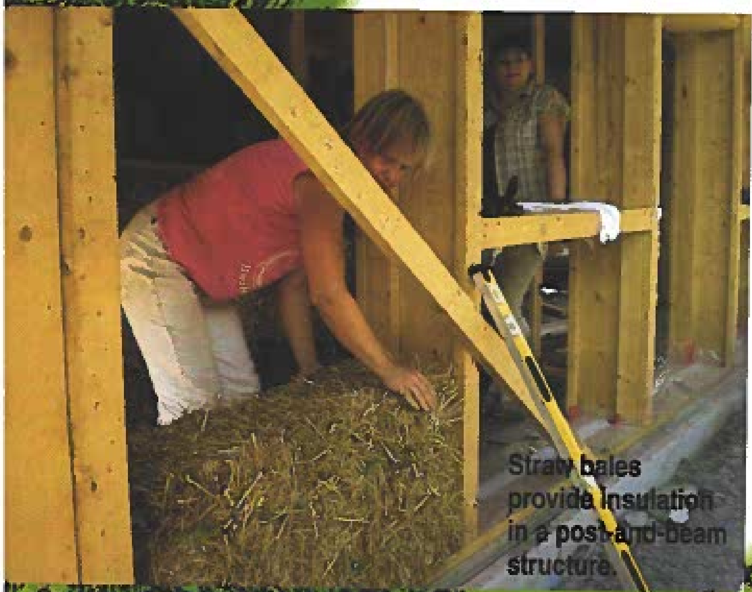
Construction

Two coats of mud plaster are applied to the straw.

Better by Design

Rena Upitis designs and builds sustainable buildings

Rena Upitis is a Canadian educator, architect, artist, and environmentalist. She believes that people must become committed to sustainable building and environmentally respectful practices. To explore this idea, Rena designed and built Wintergreen Studios, a straw-bale building that uses recycled barn beams in its structure and locally grown straw for its walls. One wing of the building is sheltered with an earth-covered living roof. In straw-bale construction, baled straw from barley, wheat, rice, flax, rye, or oats is used to build the exterior walls. The bales are then covered with mesh that is stitched on with giant bale needles. On top of the mesh, two or three coats of plaster are applied. This construction technique provides a high insulation value, so houses are warm in the winter and cool in the summer. The house is ***off-grid***. In other words, electricity is generated at the site, and the house is not connected to an electric utility.



Straw bales provide insulation in a post-and-beam structure.

"Everything I have read about energy consumption and global warming tells me that we do not have the privilege of another fifty years to think about these issues."—Rena Upitis

Reading Target

Connecting to Prior Knowledge

One good way to prepare yourself to read new material is to think about what you already know about the subject. You have probably seen new buildings or homes being constructed in your area. What do you know about home construction? Use the Reading Target at the end of this chapter to record your ideas, even if you are not sure of some of the facts.

Key Terms

adobe
batter boards
beam
closed-loop system
communication system
electrical system
floor plan
footing
foundation
heating, ventilation, and air-conditioning (HVAC) system
insulation
joist
landscaping
modular construction
off-grid
open-loop system
photovoltaic panels
plumbing system
post and lintel
prefabrication
roof truss
site
subfloor
subsystem
sustainable
system
wall studs

Objectives

After reading this chapter, you will be able to:

- Identify issues that affect the structure of a house and how it is built.
- Discuss the steps involved in planning for a home.
- Describe the structural components and materials in a typical house.
- Use a systems model to explain construction technology.
- Explain how advances in construction and building systems are affecting construction technology.

Useful Web sites:
www.strawbale.com/
www.greenplanethomes.ca/about_strawbale.htm
www.wintergreenstudios.com

Modern communities rely on people with various skills and different levels of education to build quality homes and maintain them in good condition. Carpenters, electricians, cement masons, plumbers, sheet metal workers, bricklayers, and ironworkers build houses, stores, office buildings, and other commercial and industrial structures. See **Figure 7-1**. Many of these tradespeople are licensed, certified, and bonded. They often undergo an apprenticeship and join a union, which ensures their skill and competency and also secures their wages and working conditions.

Other professionals are also involved in building homes. These include civil engineers, architects, interior designers, landscape planners. In addition, inspectors design, plan, and ensure that the buildings adhere to government guidelines, regulations, building laws, and ordinances.

The Structure of a House

Many different materials have been used for homes. See **Figure 7-2**. In the past, people have built houses from the handiest material. They used what was available nearby. In North America, a mixture of clay and straw, called ***adobe***, was used in the Southwest. Thick walls kept the home

Figure 7-1. Tradespeople build homes. A—Carpenters use wood to build the house frame, roof, and stairs and install windows, doors, and cabinets. B—Electricians install electrical and communication wiring, lighting circuits, and fixtures. C—Cement masons pour cement for foundations, sidewalks, and driveways.

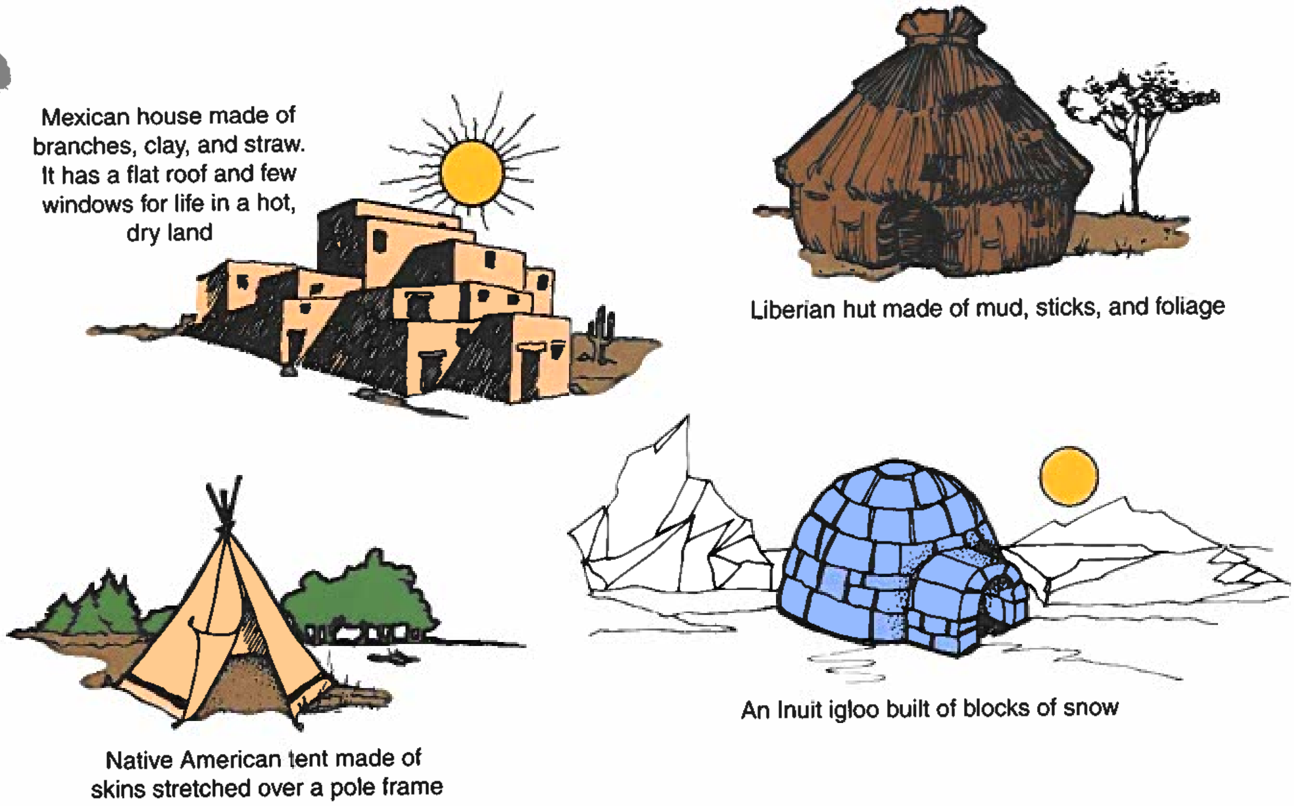


Figure 7-2. Examples of homes that were built using materials found locally. What other factors determine the shape of these homes and the materials used in their construction?

warm in winter and cool in summer. Pioneers who homesteaded the Great Plains used sod cut by plow. The sod served as walls and sometimes roofs. In wooded regions of the north where lumber was plentiful, log cabins were built. Wood is still a popular building material in North America. Treatment of the wood to retard fire and decay has made the frame house more durable than ever.

Prefabrication

Building a home entirely on its site often takes a number of months. To speed up construction, some parts or even the entire house can be built in a factory. This method of building is called *prefabrication*. It is a faster method because the parts can be made on an assembly line. Workers are not affected by bad weather.

Prefabricated parts are moved to the building site for final assembly. Time is saved in the factory because of mass production methods, and time is saved on the site because much of the assembly has already been done.

A popular type of prefabrication is known as *modular construction*. Modules are basic units, such as rooms. Modules of different sizes and shapes can be combined on site.

The House Frame

The simplest framed structure is a *post and lintel* or post and beam structure. See **Figure 7-3**. The lintel is a beam simply supported on the posts. It carries the roof load. The posts are vertical struts compressed by the lintel. Post and lintel structures may be built one on top of another to frame multistory buildings.

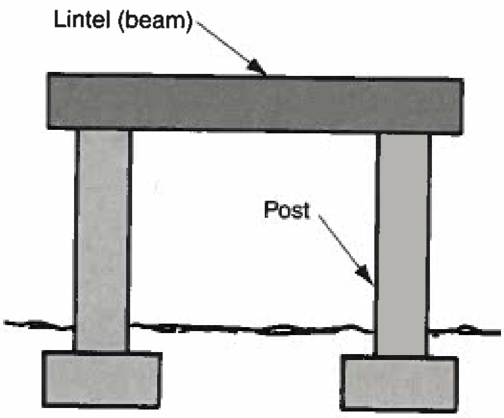
Like bridges, houses must support loads. Static loads a house must support include the weight of the materials from which it is built and its contents. The house must also withstand dynamic loads created by weather conditions outside and the movement of people inside. To understand how these loads are supported in a house, look at **Figure 7-4**.

Horizontal forces are produced by wind. Most other loads and forces tend to push downward. Loads are usually applied to horizontal members such as *joists* or *beams*. The total load then moves downward. It transfers to columns or bearing walls and then to the foundation. Finally, the load is transferred to the soil.

Think about the loads placed on the floor of your home. If you and your friends are dancing, the mass of the people acts as a load. This load is transferred to a beam, then to a column. The load on the column is transferred through the foundation wall to the footing and into the underlying soil. See **Figure 7-5**.

Planning for a Home

Before construction of a house can begin, two major decisions must be made. One is to decide on the basic type of house. The other is to plan the house *site*, or lot. A site is the land on which a house is built.



A

B

Figure 7-3. A—Heavy posts support the horizontal lintel or beam. B—Steel-framed buildings are similar to post and lintel structures.

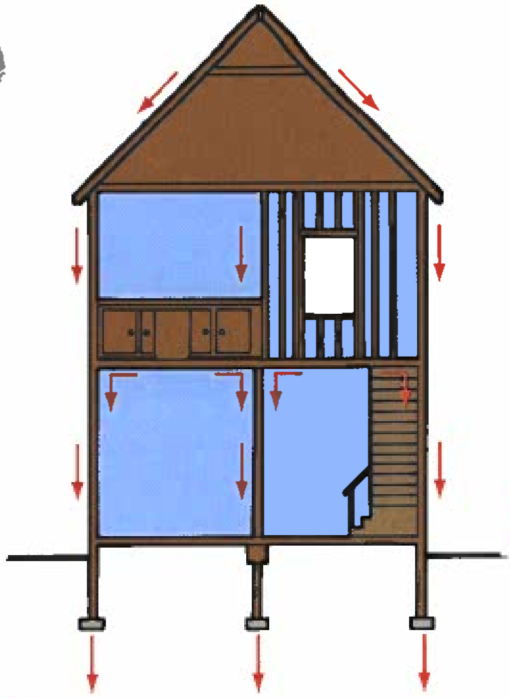


Figure 7-4. Arrows show how the load of a house is transferred to the foundation.

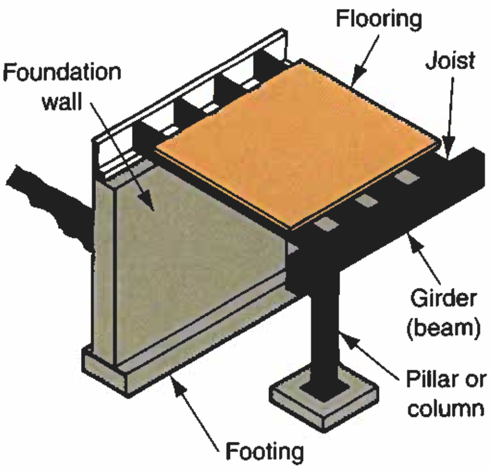


Figure 7-5. Loads from the house flow down the foundation wall to the footing, where they are transferred into the soil.

Four types of single-family houses are shown in Figure 7-6 through Figure 7-9. The type chosen is based on a number of considerations. How much room is needed? How much land is available for a home? Which type is most appealing to the family? Will any family member have difficulty with steps?

Another consideration is how much money you wish to spend. Is the money available? Banks and other lending institutions make loans for building. However, first you have to qualify for the loan.

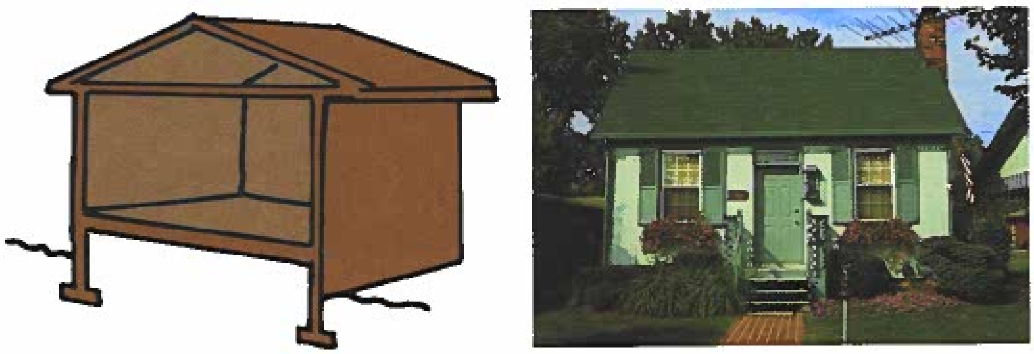


Figure 7-6. A bungalow is small and usually has only one story.

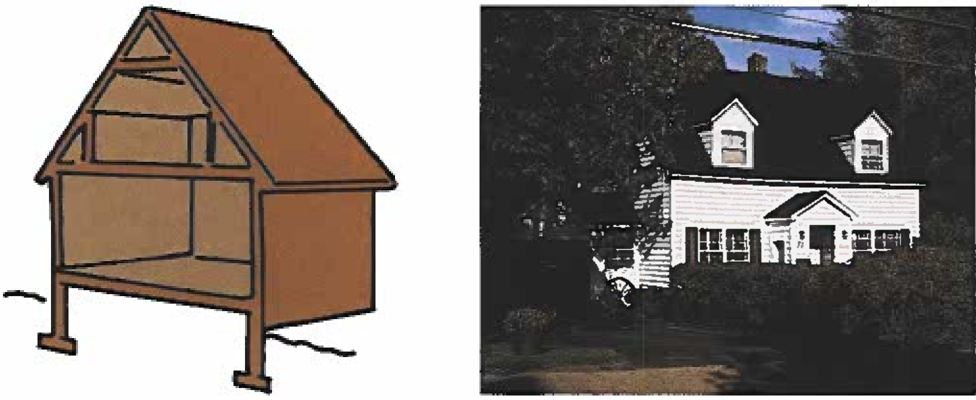


Figure 7-7. In a one-and-a-half story home, the rooms on the second level extend into the roof.

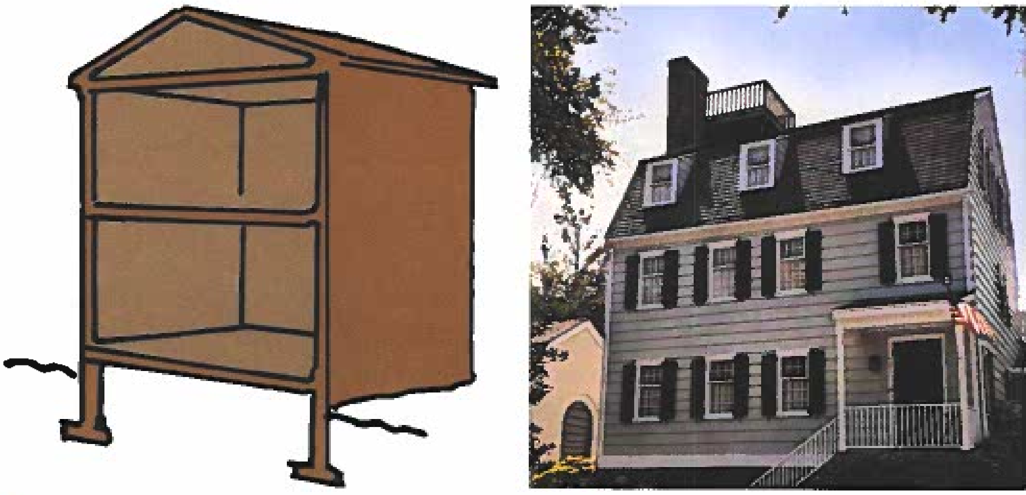


Figure 7-8. Houses may have two, three, or more stories.

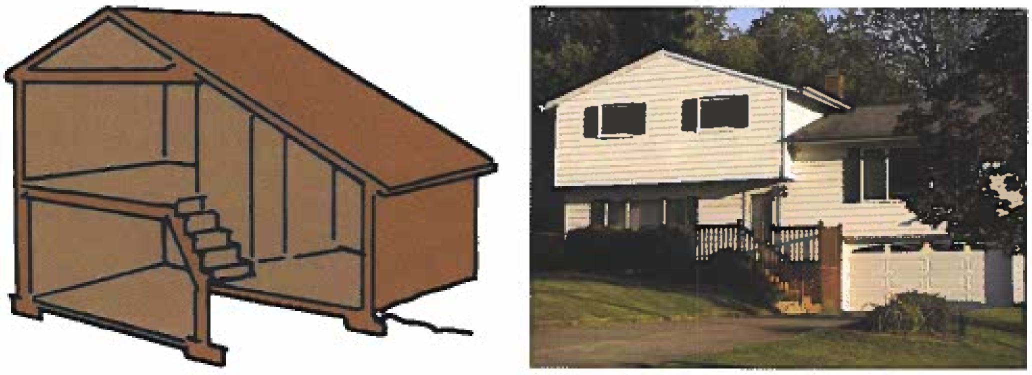


Figure 7-9. A split-level home is divided vertically. The floors of one part of the house are located midway between the floors of the other part.

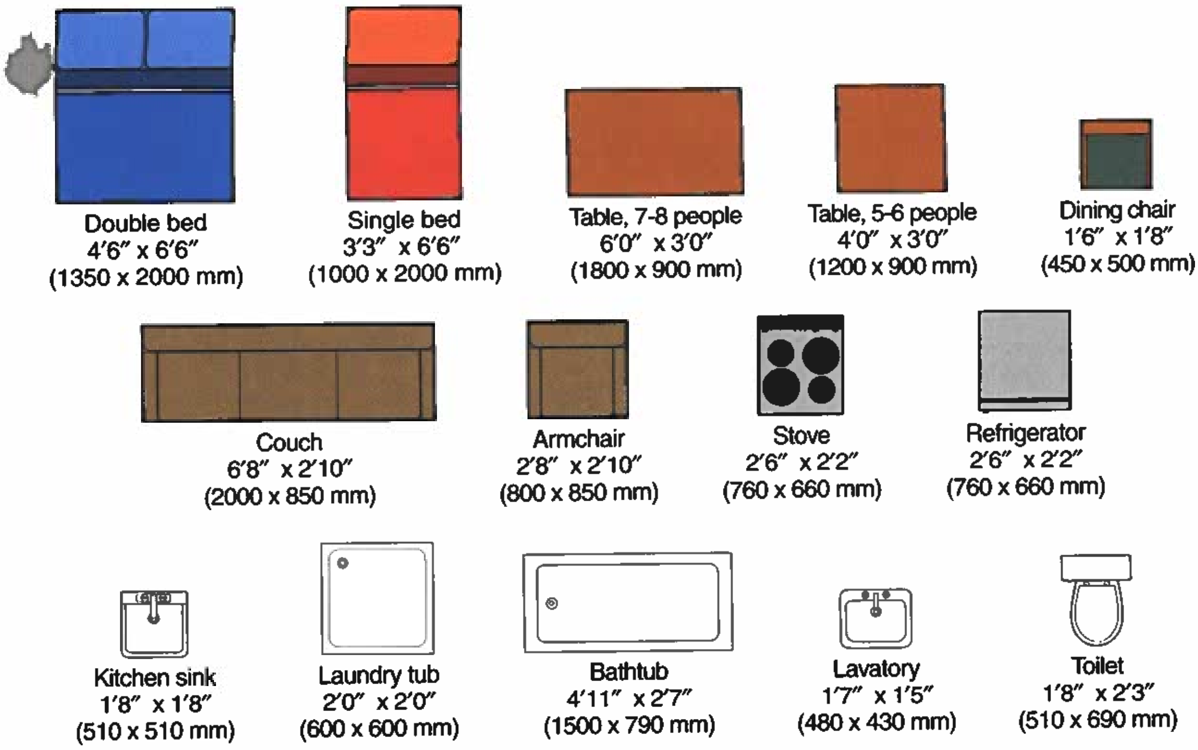


Figure 7-10. These drawings represent furniture and fixtures in a typical home. They are sometimes shown on floor plans so people can visualize how they will fit in a home.

Planning Inside Space

The second major task in designing and building a home is to plan the interior spaces. This task is often performed by an architect. What if there were no interior walls in your home and you had to divide the space into a number of rooms? How would you do it?

First of all, think about the spaces needed in a home. You must be able to fit in all of your furniture and household equipment. You should also leave sufficient space to move around. The sizes of most items of furniture and equipment are fairly standard. Figure 7-10 shows a plan view of common items and the floor space required for them.

One way to determine the overall size and shape needed for any individual room is to try out different furniture placements. Use small pieces of card stock. Cut the card stock to represent the size and shape of each piece of furniture. Position the shapes in different ways and study each arrangement. Continue until you find a suitable arrangement, remembering to leave space for people to circulate around the room. There must also be space to open doors and pass through doorways. The result provides a possible size and shape for the room. See Figure 7-11. Next, fit the rooms into the overall shape of the house. Generally, rooms are grouped according to their functions: living, sleeping, and working (food preparation and dining). Rooms are grouped for a number of reasons:

- To separate noisy and quiet areas so family members can work or play without disturbing others who are resting or studying.

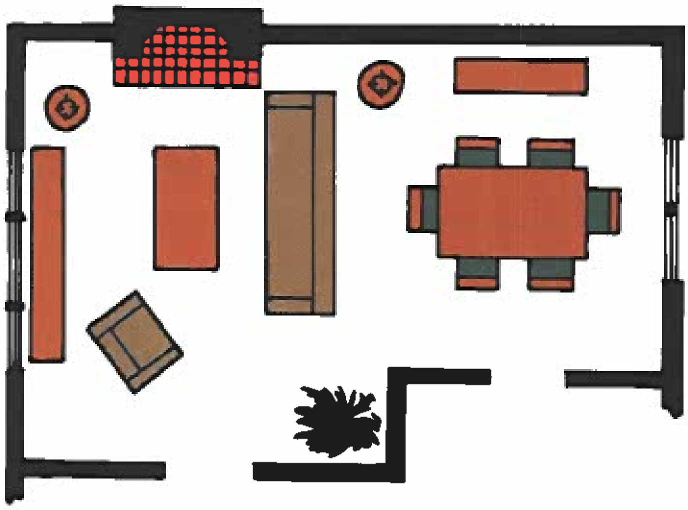


Figure 7-11. Rooms are often planned around furniture. What furniture items are shown by these symbols?

- To place bedrooms and bathrooms close to each other for convenience in washing, bathing, and dressing.
- To give direct access between kitchen and dining area for convenience in carrying hot foods from the kitchen to the table and for clearing the table.

Rooms must be connected by hallways, stairs, and doorways. In a home with good traffic patterns, you should be able to move from one area to another without passing through a third area. See **Figure 7-12**. For example, it should be possible to walk from the kitchen to the front door without going through several rooms.

When you think you have a good arrangement of rooms, you can make a drawing. An architect calls this a *floor plan*. The plan shown in **Figure 7-13** shows a floor plan for a two-bedroom apartment. **Figure 7-14** shows a floor plan for a three-bedroom bungalow.

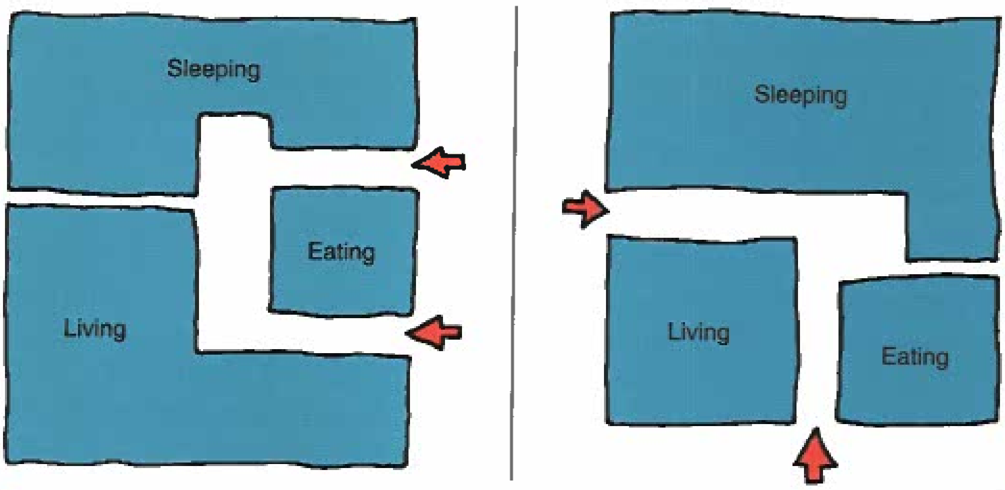


Figure 7-12. In a well-designed house, hallways allow access to all rooms without passing through other rooms.

Figure 7-13. A floor plan for a two-bedroom apartment.

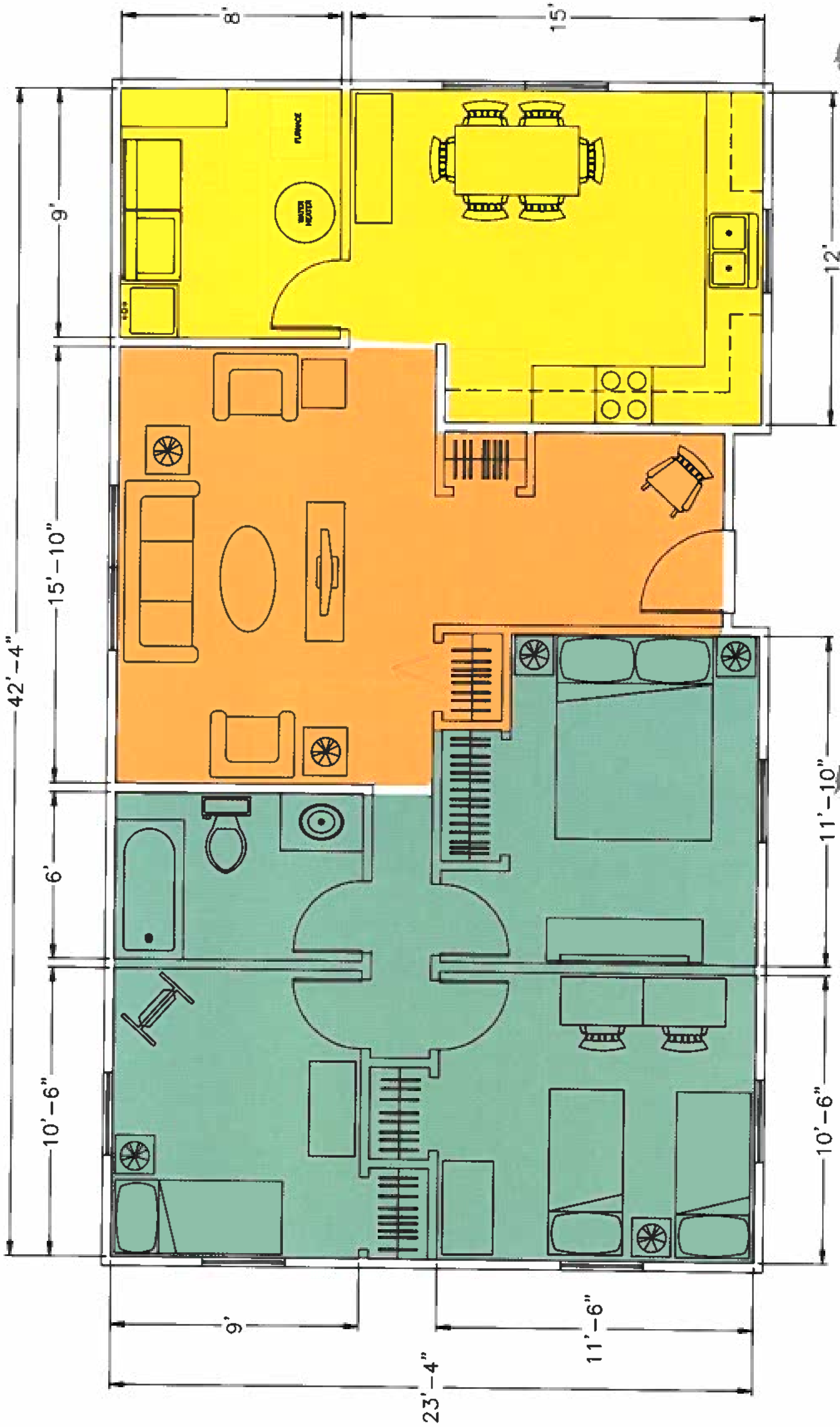


Figure 7-14. A floor plan for a three-bedroom bungalow. Why are the sleeping and living areas separated from the dining and kitchen areas?

Math Application

Floor Plan Area Calculations

The size of houses, and of rooms or areas within houses, is usually measured in square feet of surface area. An apartment may have 936 sq. ft., for example, and a mid-range house might have 1,800 sq. ft.

To find the surface area of a room, you multiply its length by its width. Therefore, if a room is 8 ft. long and 10 ft. wide, its area is $8 \times 10 = 80$ sq. ft. Before you multiply, make sure both the measurements are in the same unit. For example, on most floor plans, both length and width are given in feet. Because you are multiplying feet × feet, the unit of the answer is $ft.^2$, or square feet.

Math Activity

Floor plans are drawn to scale and dimensioned to show the sizes of rooms. Refer to Figure 7-14 and determine the number of square feet in each of the following areas. Assume that all closets are 2.5 ft. deep and the front entry is inset 2 ft. from the front of the house. Round your answers to the nearest square foot.

- Work area (yellow color)
- Living area (orange color)
- Sleeping area (blue color)

Finding and Preparing a Site

The land on which a house is built can be any size. City lots are usually small. Those outside the city may be as large as several acres. Planning the site is just as important as designing the home itself. It involves several important steps.

Selecting the Site

Where you locate a new home is important. You may want it to be in a certain community. Perhaps it should be close to your job, shopping centers, and schools. Or maybe you prefer a quiet wooded area.

Site Preparation

Site preparation means getting the site ready for the home. One of the first steps is to do a soil test. You need to know how well the subsoil will carry the weight of your home and whether there is hard rock underground. Rock may be expensive to remove. There may be groundwater too close to the surface. This could cause flooding in the house.

Once a soil engineer has determined that the site is suitable, a contractor will clear the site of boulders and excess soil. Grading may be needed to level a spot for the foundation. Lines and grades must be established to keep the work true and level. **Figure 7-15** shows how ***batter boards*** are used for this purpose. Small stakes are located at what will be the corners of the house. Nails driven into the tops of these stakes mark the four corners of the house. Straight lines between these nails indicate the outside edge of the foundation walls.

Once the four corners have been located, larger stakes are driven into the ground at least 4′ (1.3 m) beyond the lines of the foundation. The batter boards are nailed horizontally to these stakes. The boards must be level. Strong string is next held across the tops of opposite boards and adjusted exactly over the tacks in the small corner stakes. A plumb bob may be used to set the lines exactly over the nails.

Next, a saw kerf (cut) is made to mark where the string crosses the top of each batter board. Some carpenters drive a nail at this point. This is done so the strings can be removed during excavation. Later, the strings can be stretched from corner to corner, across the batter boards, to locate the corners of the building once again.

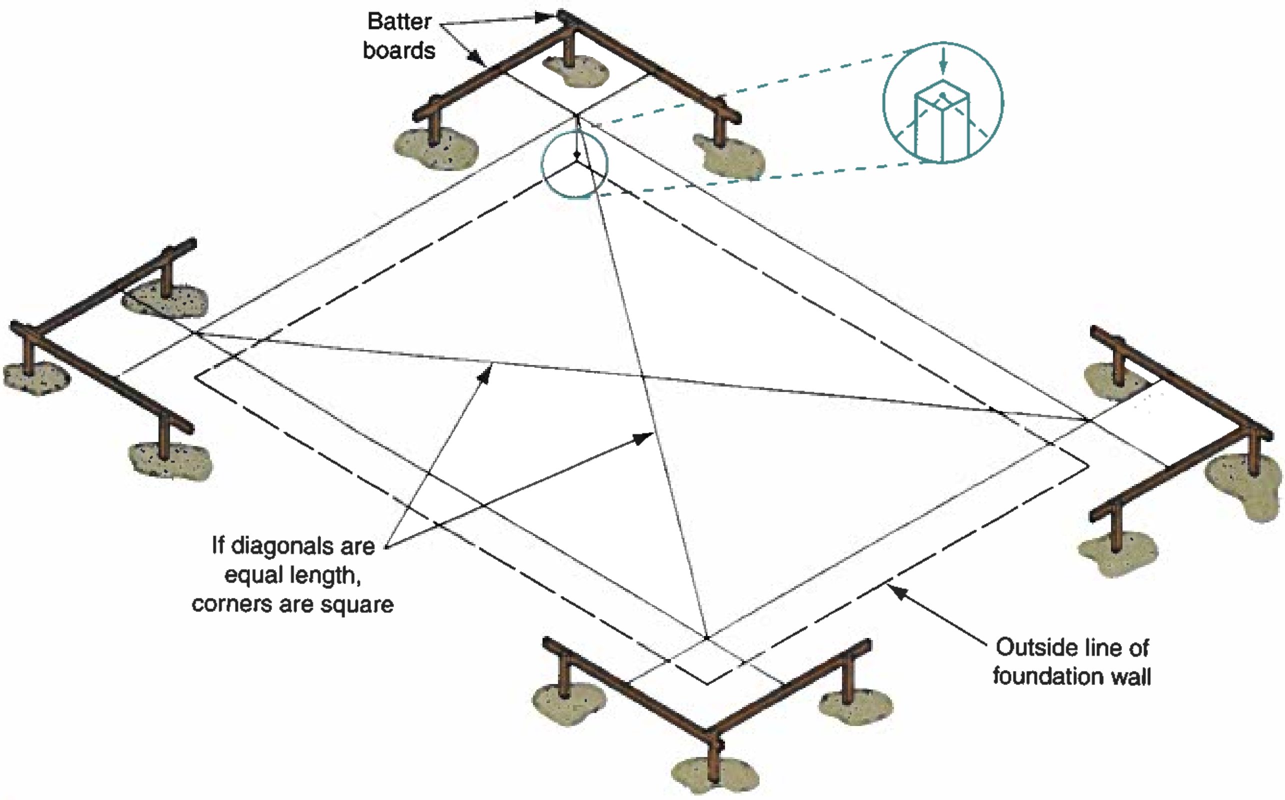


Figure 7-15. Batter boards support the lines set up to locate the building so excavating can begin for the foundation.

Structural Components and Materials

Buildings have five major components: foundation, floor, wall, ceiling, and roof. See Figure 7-16. The two materials most commonly used for house construction are concrete and wood.

Foundation

Most structures rest on a *foundation*. See Figure 7-17. Normally a foundation lies below the surface of the ground. Notice that there are two major parts to this type of foundation: the *footing* and the foundation wall.

To understand the importance of the footing, think about the reason for wearing snowshoes. See Figure 7-18. If you try to walk on deep, soft snow without them, you might sink down to your knees. Snowshoes spread your body mass over a larger area of the snow's surface. This prevents you from sinking.

The same principle is used to build a foundation. The load of the building is first transmitted to the foundation wall. Then it is spread over a larger area by the footing. Thus, the building is prevented from sinking into the ground.

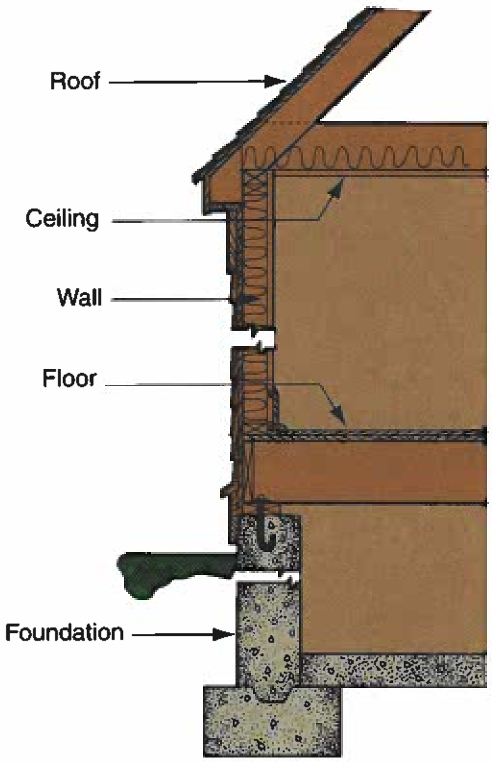


Figure 7-16. A section through a typical house shows its main structural parts.

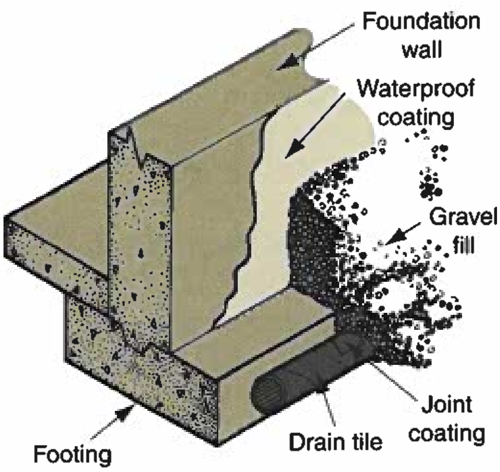


Figure 7-17. Many foundations are of this type. Why do you think the footing is so much wider than the foundation wall?

Figure 7-18. The function of a foundation wall is similar to that of snowshoes. Why doesn't this boy sink into the snow?

In most locations, it is necessary to drain away any subsurface water to avoid damp basements and wet floors. Tile laid around the wall footings serves this purpose. These are known as drain tile, perimeter tile, or weeping tile.

The two materials most commonly used for foundation walls are poured concrete and concrete blocks. Concrete is strong in compression, so it can support heavy loads. As you read in the previous chapter, embedding steel rods or wire mesh in concrete increases its tensile strength (strength in tension). The various parts of foundation walls, their functions, and the materials used in their construction are summarized in Figure 7-19.

In warm climates, there is either no frost or the frost does not penetrate very far below the ground. Therefore, a combined slab and foundation is commonly used. See Figure 7-20.

Part	Function	Material
Foundation wall	To form an enclosure for the basement and to support walls and other building loads	Concrete Concrete blocks
Footing	To transmit the superimposed load to the soil	Concrete
Drain or perimeter tile	To provide drainage around footings	Clay Plastic
Gravel fill	To permit water to drain into the drain tile	Gravel

Figure 7-19. The parts of a foundation.

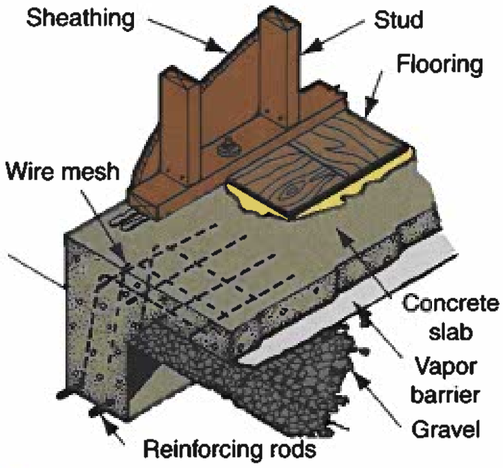


Figure 7-20. Where frost does not penetrate deeply, a combined slab and foundation can be used. In what parts of the country might you find these slab foundations?

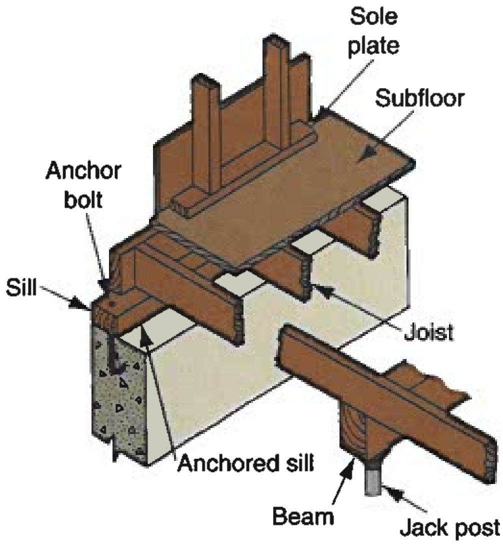


Figure 7-21. A floor is supported by joists.

Floor

When the concrete for the foundation wall is poured, anchor bolts are set in the top. These bolts are used to fasten a sill to the foundation, as shown in Figure 7-21. Joists are nailed to the sill on edge, forming a framework. This framework is supported by a beam. Joists are usually made of wood nearly 2″ thick and 10″ wide or more. When joists must span a long distance, they are supported in the middle by jack posts.

The joists support a *subfloor*. A subfloor is a covering over the joists. It supports other floor coverings. The various parts of floors, their functions, and the materials used in their construction are summarized in Figure 7-22.

Part	Function	Material
Beam	To support joists when long distances are spanned	Wood (pine or spruce) Steel
Joist	To support a floor	Wood (pine or spruce)
Subfloor	To support finish flooring	Board or sheet material (tongue-and-groove pine, plywood)
Sill	To support joists where they meet the foundation	Wood (pine or spruce)
Jack post	To support beams	Wood (pine or spruce) Steel

Figure 7-22. Parts of a floor frame.

Walls and Finish Flooring

The subfloor is fastened to the joists. Then the walls for the first floor are laid out and built. The many parts of this type of wall are shown in Figure 7-23.

Wall studs provide the framework for walls and partitions. The other various parts of walls, their functions, and the materials used in their construction are listed in Figure 7-24.

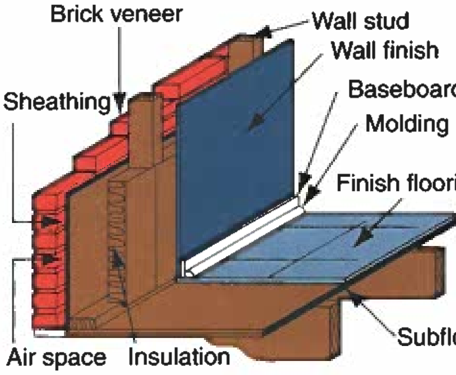


Figure 7-23. A section of a wall and floor.

Part	Function	Material
Exterior surface	To provide protection and decoration to the outside of a building	Brick Aluminum siding Wood
Air space	To provide a barrier against the passage of moisture	
Sheathing	To reinforce studs To provide insulation	Wood Fiberboard
Wall stud	To provide a framework for walls or partitions	Wood (pine or spruce)
Insulation	To resist heat transmission	Fiberglass Polyurethane Vermiculite
Vapor barrier	To retard the passage of water vapor or moisture	Polyethylene Sheet
Interior wall surface	To cover the interior wall framing	Plasterboard Wood paneling Plaster
Finish flooring	To cover a subfloor and provide a decorative surface	Parquet Ceramic Linoleum Carpet

Figure 7-24. Parts of walls and finish flooring.

Math Application

Multiplying Decimals

Housing contractors such as bricklayers, plumbers, and roofers generally submit bids on housing projects they want to work on. The bid includes:

- Total cost of materials
- The number of hours needed to complete the job
- A labor rate, or cost per hour for the contractor to do the work

If the contractor calculates any of these items incorrectly, he may either underestimate or overestimate. Neither is good. For example, if he underestimates the cost of materials, then he won't make enough money to profit from the job. If he overestimates the cost of materials or the number of hours needed, his bid may be too high and he won't get the job.

Therefore, contractors need to be able to multiply and divide accurately, and many of their calculations involve decimals. The process of multiplying and dividing decimals is almost the same as multiplying whole numbers. The only difference is in determining the number of decimal places in the answer.

To multiply decimals, first multiply in the same way that you would with whole numbers. Next, total the number of decimal places to the right of the decimal point in both of the numbers being multiplied. Locate the decimal point by counting from the right end of the number. For example, suppose a plumber estimates that a job requires 52.75 feet of pipe. With his contractor's discount, he can buy the pipe for $1.62 per foot. How much will the pipe for this job cost?

```
   52.75    ← Total of four digits to the right of the decimal point
 x  1.62
   10550
  31650
  5275
  85.4550   ← Put decimal point four places from the right
```

Math Activity

Practice multiplying decimals by performing the following calculations. Then check your work using a calculator.

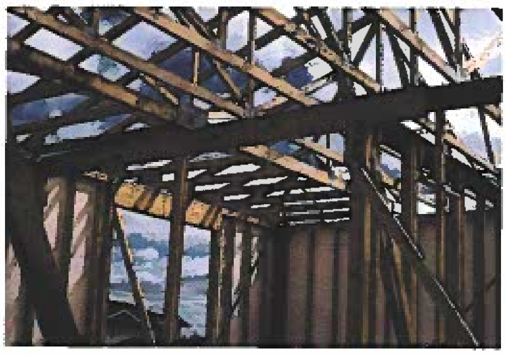
1. If a bricklayer can lay, on average, 150 bricks/hr., how many bricks can she lay in a 35.5-hour week?
2. A roofer used 10.75 sheets of plywood on a reroofing job. If the plywood cost $25.40 per sheet, what was the total cost of the plywood?
3. If a plumbing pipe costs $1.74 per foot, what is the cost of 25.5 feet of pipe?

Ceiling and Roof

Like floors, ceilings often require joists. A roof is made up of sloping timber called *rafters*. Roofs can also be built of a series of prefabricated trusses. Shaped like a triangle, the *roof truss* forms a framework to support the roof and any loads applied to it. Braces on the inside create further triangles to support and strengthen the rafters.

A typical ceiling and roof construction is shown in Figure 7-25. The various parts of ceilings and roofs, their functions, and the materials used in their construction are described in Figure 7-26.

Figure 7-27 shows how all the many parts of a house fit together. The next time you see a building being constructed, see how many of the parts you can identify.



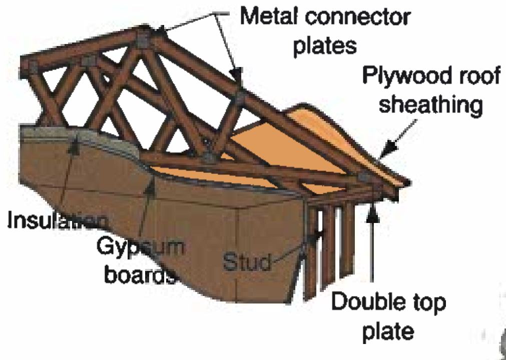


Figure 7-25. Recall what you know about bridge design. Why is this type of roof called a truss roof?

Part	Function	Material
Joist	To support a ceiling	Wood (pine or spruce)
Insulation	To resist heat transmission	Fiberglass Polyurethane Vermiculite
Vapor barrier	To retard the passage of water vapor or moisture	Polyethylene Sheet
Interior surface	To form the ceiling	Plasterboard plaster
Roof truss	To form a framework for the roof and to support loads applied to it	Wood (pine or spruce)
Exterior finish	To provide protection from rain, snow, and other weather conditions	Asphalt Wood Shingles Tar and gravel

Figure 7-26. Information about the parts of a ceiling and roof.

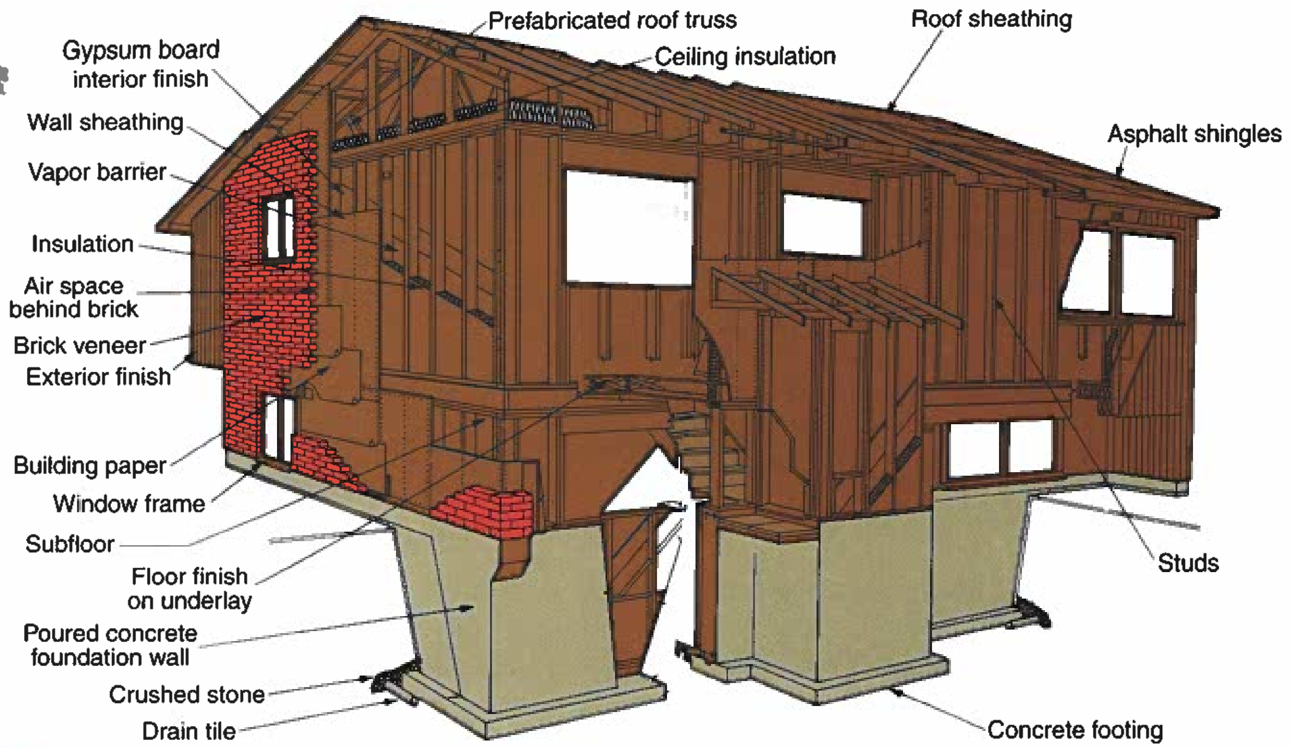


Figure 7-27. The parts of a house and how they fit together.

Finishing the House

The final stages in building a house include trimming, painting, decorating, and landscaping. Trimming involves covering rough edges and openings with moldings. For example, a baseboard is the trim used to cover the small space between a wall and a floor. Painting protects and improves the appearance of interior and some exterior surfaces. Wallpaper is also a common interior decorating material. Paneling or tongue-and-groove boards are also used to provide a finished surface for walls.

Landscaping, **Figure 7-28**, is a design for the exterior space that surrounds a home. It involves planning the location of lawns, hedges, trees, shrubs, and plants. The plan shows the location of accesses such as driveways and walkways. It also shows special features such as patios, fences, walls, and plant boxes.

After accesses and features have been built, topsoil is added to the site. Topsoil is a layer of rich earth. It is needed so that trees, shrubs, lawns, and plants can grow. Then the plants are added to finish the landscape.

Maintaining a House

Even after a house is built, the work is still not complete. All houses, even new ones, require maintenance. Some work, such as cleaning, is required weekly. Heating systems require annual check-ups. Some maintenance is done only when the need arises, such as when a light bulb burns out.

Figure 7-28. A well-landscaped house has flowers, shrubs, trees, ground cover, and walkways that are in harmony.

Materials and equipment age, wear out and break down. That is why people should learn to maintain their homes. Typical home maintenance jobs include:

- Replace old carpet
- Repaint walls and ceilings
- Replace blown fuses
- Rewire circuits to meet updated building codes
- Repair concrete cracks
- Change air filters in furnace
- Install more insulation in walls or ceilings

You can save money by doing some of these maintenance jobs yourself instead of hiring a contractor. It can also bring you personal satisfaction for a job well done, whether you are working on your own house or helping a friend. There are other important reasons for keeping your home well maintained. If you plan on selling your house, a home inspector will come and check everything from electrical, plumbing, drywall, roof, carpentry, and furnace, hot water heater, and exhaust ducts. You will be required to repair or replace whatever is not up-to-date with the code.

Systems in Structures

What happens when you telephone a friend? After lifting the receiver or pressing a button, you dial a number. Signals travel to a central location where automatic switching equipment sends your call to your friend's house or cell phone. Your friend answers and your voices are carried over the lines or airwaves. At the end of the conversation, the caller disconnects. The telephones, cables, and automatic switching equipment are part of a *system*.

Some systems are very large. Others are quite small. The sun and the planets that revolve around it form the solar system. The skeletal system of your body is made up of more than 200 bones. Together, they support the body's mass. They also give the body shape and protect important organs.

The fuel system of a car is a system. It pumps gasoline from a fuel tank, through fuel lines, to the injectors and into the cylinders of the engine. The fuel system is connected to other car systems, such as the brake system, to make the car operate smoothly. This is an example of how technological systems can work together to accomplish a task.

To work successfully with any kind of system, it is important to think about how each part of the system relates to all the other parts. A problem in any part of a system can affect the entire system.

Types of Systems

Every system is a series of parts or objects connected together for a particular purpose. There are two types of systems: open-loop and closed-loop. See **Figure 7-29**.

Open-Loop System

A portable space heater without a thermostat is an example of an ***open-loop system***. When it is plugged in and switched on, the heating element warms the air passing over it. It continues to heat the room until switched off. There is no method of controlling whether there is too much or too little heat.

Closed-Loop System

In a ***closed-loop system***, the same heater would be connected to a control mechanism such as a thermostat. When the room air reaches the temperature you set on the thermostat, the heater shuts off. It will switch itself on again when the temperature falls below the set limit.

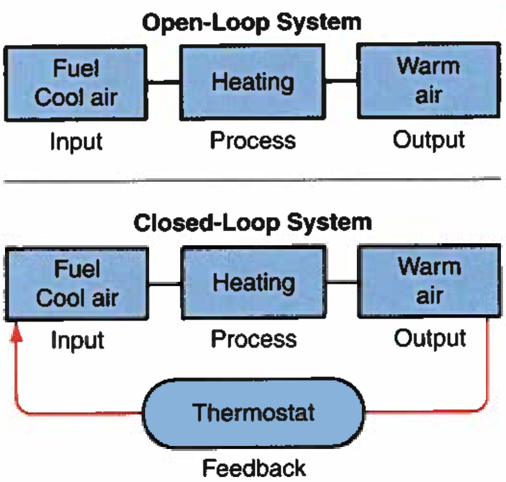


Figure 7-29. Comparison of open-loop and closed-loop systems.

In both cases, the systems contain input (cool air and fuel), process (burning the fuel), and output (warmed air). Input, process, and output are characteristics of all systems. However, in a closed-loop system there is also a feedback device, which provides control.

Control of our environment is a major reason why technological systems have been created. Controls in technological systems, such as the thermostat in a heater, allow us to change the system. For example, the thermostat uses information about the air temperature to operate the heater and maintain a comfortable temperature.

In our homes, there are four major systems:

- Heating, ventilation and air conditioning (HVAC)
- Electrical
- Plumbing
- Communication

Heating, Ventilation, and Air-Conditioning Systems (HVAC)

Figure 7-30 illustrates the major parts of a forced air *heating, ventilation, and air-conditioning (HVAC) system*. Some heating systems use water to carry heat throughout a house. However, forced air is a more popular way to move heat from a furnace to various rooms.

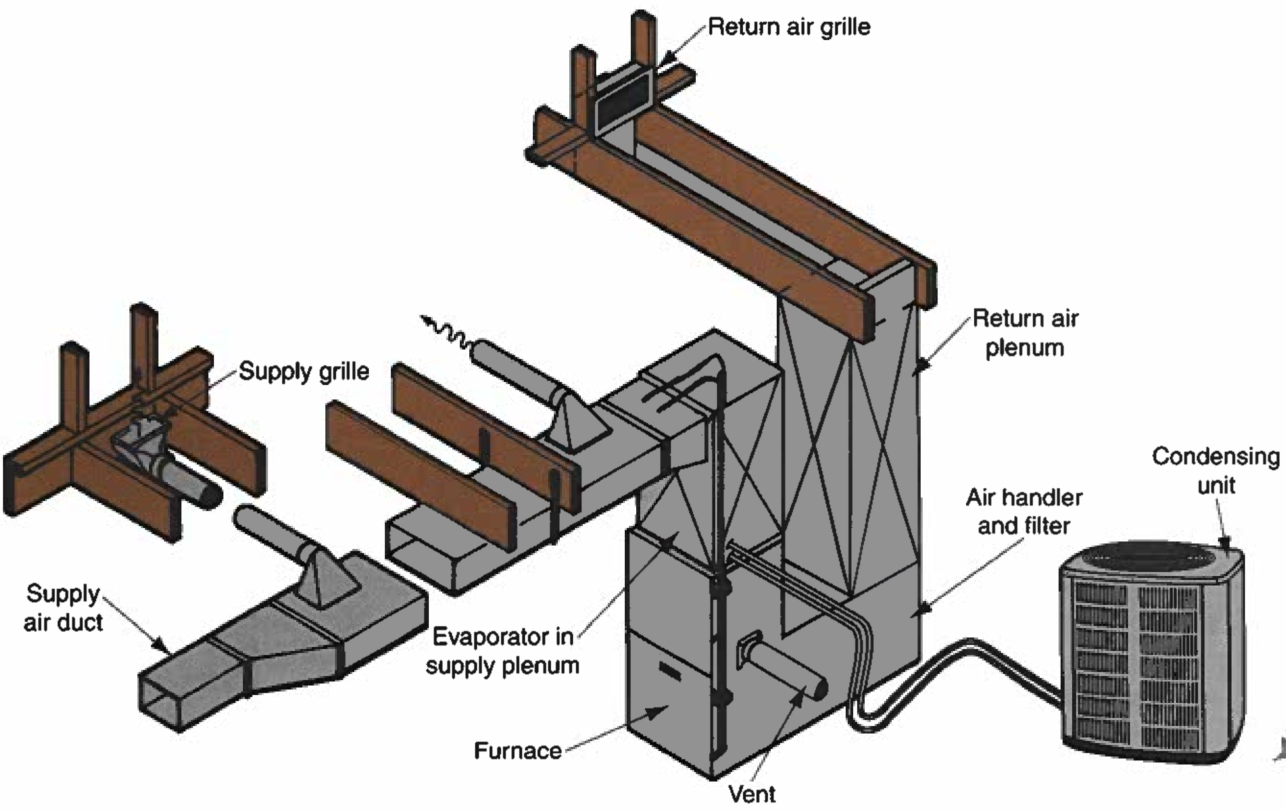


Figure 7-30. Central air conditioning and heating system. Air is conditioned and carried to all rooms of a house.

Cool air enters the bottom of the furnace. Here the filter traps dirt. A blower forces the filtered air up into a compartment, called a *heat exchanger*. The exchanger has passageways that are heated by electricity or the combustion gases from burning oil or gas. The blower forces the warmed air through a network of ducts into each room. Cooler, heavier air sinks to the floor and flows through return air ducts leading back to the furnace. Control switches turn on the blower and the supply of heat. Thus, the furnace controls the temperature of the circulating air.

An important part of any HVAC system is the *insulation*. Insulation is material installed in walls and ceilings to help control heat loss in winter and heat gain in summer. Some common forms of residential insulation are blanket, batt, rigid, and loose fill. Insulation is commonly made from fiberglass, Styrofoam®, treated paper, and a variety of other materials.

The HVAC system is, in fact, composed of several subsystems. A *subsystem* is a smaller system that operates as a part of the larger system. A home HVAC system contains some or all of the following subsystems.:

- Heater to produce heat
- Air conditioner
- Blower unit to push the heat through the ductwork
- Network of ducts to carry the conditioned air
- Thermostat to provide continuous feedback
- Humidifier
- Electronic filter
- Heat pump

Electrical System

An *electrical system* supplies electricity for light, heat, and appliances. Electricity is carried throughout the home by a number of separate circuits. A circuit is a pathway for electrical current. Each circuit normally has a cable with three wires (positive, negative, and ground) running inside the walls and ceilings.

A circuit carries current from a power source, as shown in **Figure 7-31**. Electric current travels to lights, motors, or heaters and back to the source. To supply these circuits, electricity from a utility company's wires must pass through a meter and a service panel. The service panel distributes the power among the separate home circuits. Lamps, television sets, and small appliances are connected to 120 volt, 15-ampere circuits. Appliances, such as refrigerators, toasters, and power tools, are connected to 120 volt, 20-ampere circuits. Separate 240 volt, 30-ampere circuits are provided a clothes-dryer or an electric range.

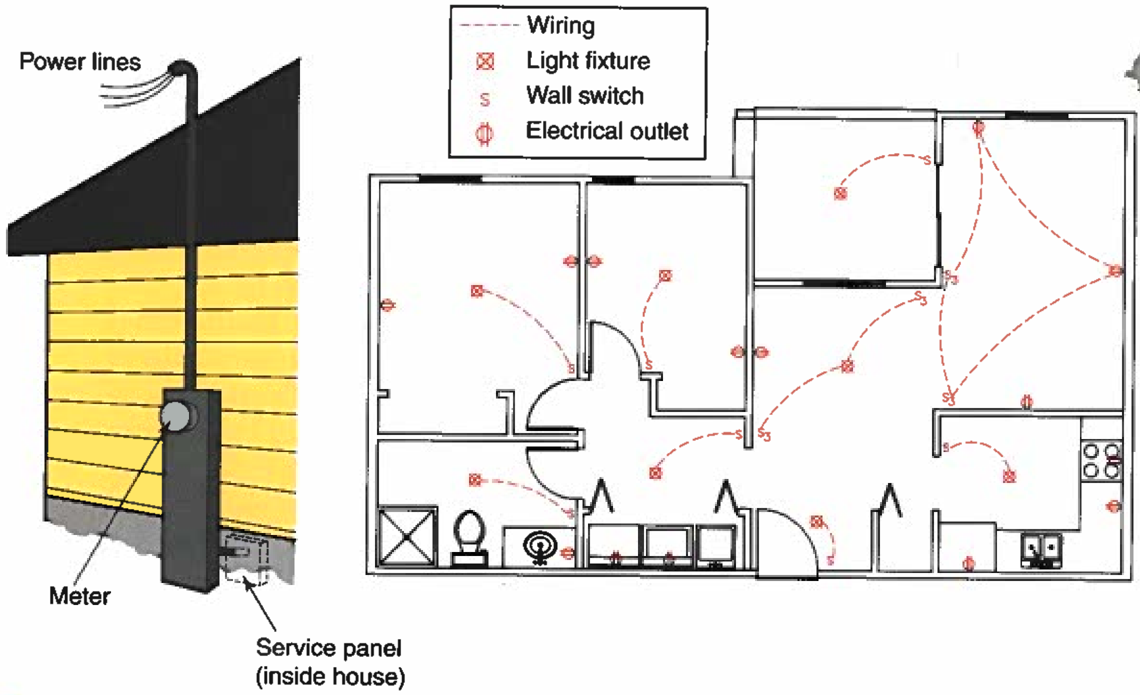


Figure 7-31. The parts of an electrical system.

Plumbing System

The *plumbing system* consists of major subsystems: the water distribution system and the drainage system. The water distribution system brings (drinkable) water into the home. See Figure 7-32. It is piped directly to all the faucets and outlets, such as sinks, toilets, baths, and washing machine. It is also piped to the hot water heater. From this heater, heated water goes to all hot-water faucets, the washing machine, and the dishwasher. The used water is drained from the house and disposed of by the drainage system.

Communication Systems

The *communication systems* in a home may include the telephone system, the radio and television broadcasting system, an Internet connection, a home PC network, and the cable or satellite television system. Telephone service is provided to most homes by copper wires or fiber optic cables. A nationwide switching system enables the telephone to be connected to any other telephone. The same copper or fiber cables can be used for data transmission so that any home can have access to a national or international computer network.

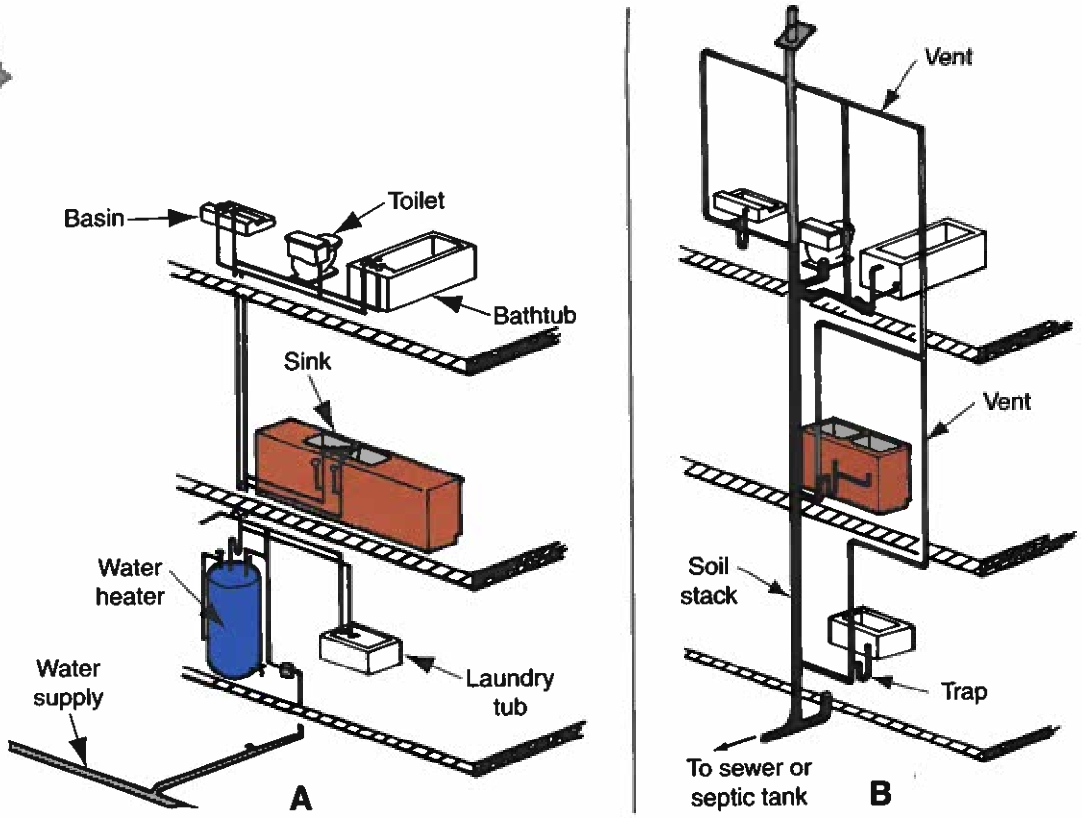


Figure 7-32. Residential plumbing system. A—Water distribution subsystem brings fresh water to different rooms in the home. B—Drainage system carries away wastewater.

Radio and television signals are received in each home. The programs may be broadcast from local stations. Satellites, antennas, and cables allow you to receive live and instantaneous radio and television coverage of events from around the world. See Figure 7-33.

Advances in Construction and Building Systems

Advances in other areas of technology continually affect construction and building systems. "Smart buildings" are now possible with new microelectronics. Environmental concerns have prompted other new technologies, including "green" materials, processes, and structures.

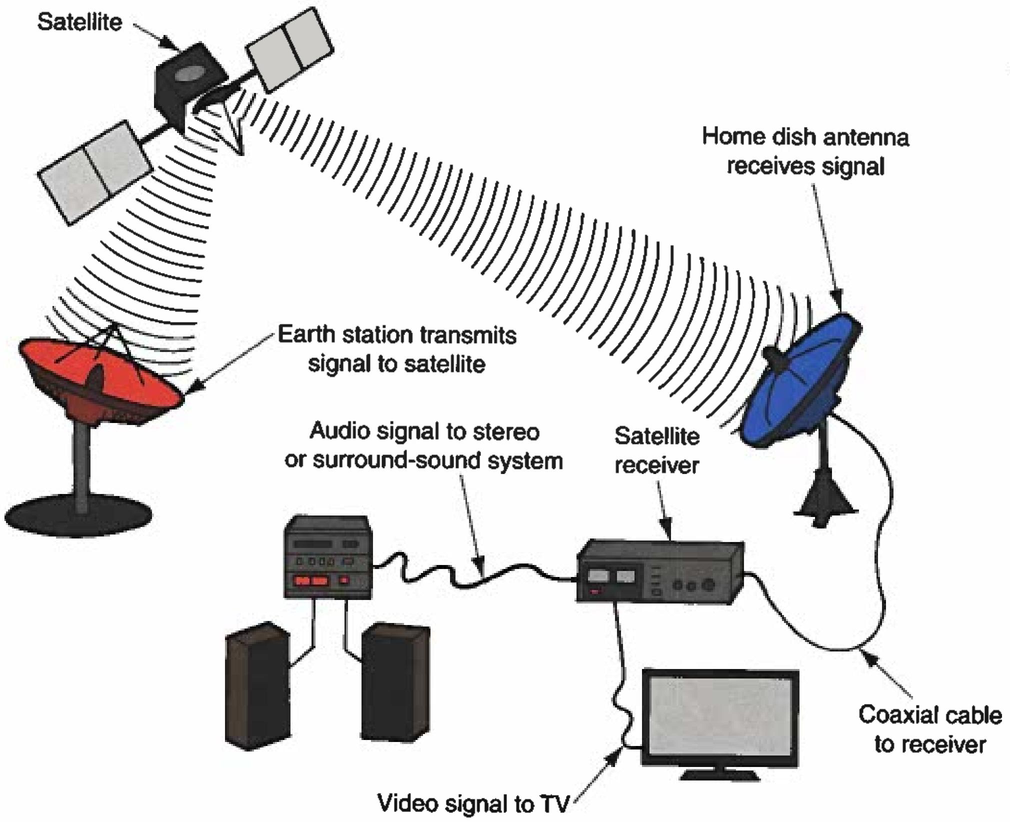


Figure 7-33. A telecommunication system can be linked to a satellite in space. Signals can be received in an instant in spite of great distances.

Automated Systems: Smart Buildings

In the early 1970s, the microprocessor was developed. Complete electronic circuits were etched on a tiny slice of silicon called a *microchip* or *chip*. Over the years, these chips have become smaller and more powerful. The microchip is now so small that it can be embedded into almost any device. This enables automatic control, programming, and connection to just about anything.

Think about the center of the home: the kitchen. A refrigerator could suggest what meal might be cooked based on what is stored inside and display the ingredients on its video screen. Cupboards could be designed so that when food is consumed, it is automatically reordered from an online grocer. Microwave ovens could scan the bar code on the food packaging and set themselves to the correct power level and cooking time. Such devices are not fantasies. They could be made right now using existing technologies. Imagine a "kitchen command center" that would include a microwave with a flat computer screen enabling online shopping, banking, and e-mail!

"Green" Buildings

Builders are becoming more environmentally conscious and are seeking alternatives to material-intensive standard practices. Pressure from society to conserve natural resources has resulted in wider acceptance and use of "green" alternatives. One green building rating system is the Leadership in Energy and Environmental Design (LEED) system of the U.S. Green Building Council.

A green home provides the following benefits:

- Uses less energy, water, and natural resources
- Creates less waste
- Is healthier and more comfortable for its occupants

Benefits of a LEED home include lower energy and water bills, reduced greenhouse gas emissions, and less exposure to mold, mildew, and other indoor toxins.

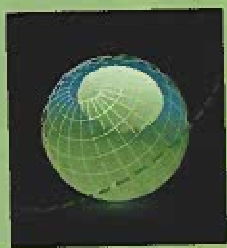
In building a green home, an initial concern is how to place a building on its lot. The windows are oriented to make use of available daylight, minimize artificial lighting and cooling requirements, and increase the R-value of the insulation.

Sustainability, sometimes, called *sustainable development*, is an important part of LEED-certified buildings. Sustainability means using resources to meet current human needs, while preserving the environment so that these needs can continue to be met in the future. It means considering the potential for long-term maintenance of human well-being. This, in turn, depends on the well-being of the natural world and the responsible use of natural resources.

Commercial LEED-certified buildings make use of air source heat pumps that extract and recycle up to 80 percent of waste heat from the building's air stream before it leaves the building. Other sustainable features include geothermal heating, low-flow washroom fixtures, rainwater

Think Green

Sustainable Lumber



One way to incorporate green building practices into a building project is to use certified sustainable lumber. A number of forests around the world are now being managed sustainably. Although they represent only a small percentage of the forests being harvested, the number is growing. It is now possible to specify certified sustainable lumber for residential and commercial construction projects.

Not all "certified" lumber is equally sustainable, however. Look for well-established certification labels such as those offered by the Sustainable Forestry Initiative (SFI) and the Forest Stewardship Council (FSC). These two independent groups certify that lumber was planted, grown, cut, and renewed in a way that protects the forest's long-term health. They also guarantee that the "chain of custody" from the forest to the wholesale or retail store includes only companies that use responsible environmental practices.

collection, and use of fly ash (a waste material from power plants) in concrete.

Solar panels, or *photovoltaic panels*, harness the sun's energy. Solar panels that can generate electricity from the sun and also provide shade are a favored method. They can be made in many forms, including opaque or clear glass, asphalt-like shingles, and other elements that replace normal parts of a building shell. The electricity produced, even under cloudy conditions, generates current for lights and small appliances. Inside the building, sensors can measure the amount of natural light coming into the building and control the amount of electrical lighting.

Rooftops are also "going green." See **Figure 7-34**. Roof surfaces provide space for gardens, including grass, flowers, and shrubs. Roof gardens help control the temperature inside the house, and the plants conserve water and clean the air. The design of green roofs is more complicated than ordinary roofs. They must have several layers that provide the right structural support, waterproofing, and drainage. Nevertheless, they are starting to become popular. For example, Chicago has more than 2.3 million sq. ft. (214,000 sq. m) of "green" rooftops.

Figure 7-34. In addition to their other advantages, green roofs provide a space to grow vegetables and herbs.

End Note

The structure of a house must support the loads of the materials from which it is built plus its contents. It must also support the dynamic loads created by the weather conditions outside and the movement of people inside. In the past, the structure of homes was influenced by locally available materials.

Homes today contain four basic systems: HVAC, plumbing, electrical, and communication. Green building materials are being used to reduce waste and increase energy efficiency. Straw bale homes use one type of green building materials. They have insulation values that are more than double that of standard wood frame homes so they use less than one half of the heating and cooling energy.

Future homes will incorporate wireless communication. Perhaps when a visitor rings the doorbell, his or her photo will be taken and beamed to the homeowner's cell phone, whether he or she is at home or far away. The owner could choose to unlock the door or just chat on the phone. A house system, operated by a universal remote, will coordinate lights, security, and the HVAC. Using light-emitting diodes (LEDs), the color of interior walls might be changed to match the owner's mood or that of the visitor's. In the laundry room, washers and dryers will be able to read radio frequency identification (RFID) tags on clothing and make adjustments to clean the clothes appropriately. Similarly, in the refrigerator, RFID tags may keep tabs on the freshness of foods and notify the owner of any expiration dates.

Summary

- In the past, the structure and materials used in a house depended on climate and locally available materials. Prefabrication techniques allow parts of a house to be prepared off-site and then assembled at the building site.
- Planning for a home includes planning the inside space and finding and preparing a building site.
- The five major components of a house are the foundation, floor, walls, ceiling, and roof.
- Types of systems in residential building construction include HVAC, electrical, plumbing, and communication systems. These systems can be open-loop systems or closed-loop systems.
- Advances in various fields can be put to use in "smart buildings." Builders are beginning to use technology and new—and sometimes very old—techniques to make buildings "greener" and more efficient.

Reading Target

Connecting to Prior Knowledge

Copy the following graphic organizer onto a separate sheet of paper. Allow space in each row for one or more sentences. Before you read the chapter, write sentences in the first column to record your current knowledge about home construction. As you read through the chapter, record new concepts you learned by reading the chapter. When you are finished, review the chart to see how much you have learned. If you have questions about topics in the chapter, record your questions at the bottom of the chart. Ask your questions in class or do research on your own to find the answers.

What I Know (Or Think I Know) about Home Construction	What I Learned in This Chapter
Structure of a Home:	
Planning for a Home:	
Components and Materials for a Home:	
Systems Used in a Home:	
Recent Advances in Home Construction:	
Further Questions:	

Test Your Knowledge

Write your answers to these review questions on a separate sheet of paper.

1. What factors determined the use of a particular material when early settlers built their homes?
2. Sketch and name the parts of a post and lintel structure.
3. List two static and two dynamic loads that a typical house must withstand.
4. List four types of single-family houses.
5. How could you plan alternative arrangements of furniture in a room?
6. Why are rooms in a home grouped by function?
7. Describe the similarity between the footing of a foundation wall and a pair of snowshoes.
8. Why is a portable space heater without a built-in thermostat an example of an open-loop system?
9. What do all systems have in common?
10. What is the difference between a smart building and a green building?

Critical Thinking

1. What characteristics do reinforced concrete buildings have in common with post and beam structures?
2. The R-2000 standard is a Canadian energy efficiency standard that has been adopted by other countries, including parts of the United States. Research this standard to find out more about its requirements. Then suggest ways of bringing existing homes into compliance with the R-2000 standard. Do not limit your list to methods currently in use. Instead, use your imagination to think of as many "green" solutions as possible.
3. "Green" structures and building procedures are becoming more and more common. Think about how cultural, social, economic, political, and historical factors, as well as the environment, have contributed to the popularity of "building green." What role has technology played? Write an essay about the impact of these factors on green construction.

Apply Your Knowledge

1. Draw and label the parts of a house foundation.
2. Collect four pictures to illustrate the types of single-family homes described in this chapter.
3. Building laws and codes control many aspects of the systems in a home. The building codes that apply in your area may be national, state, or local codes, or a combination of all three. Find out what building codes apply in your area.If possible, obtain a copy of local codes and read the requirements. What requirements are specific to your local area? Why might local codes not need to be included in national requirements?
4. Use the systems model shown in Figure 7-29 to describe how a spaghetti dinner is prepared.
5. Select a technological system in which two or more systems work together. Evaluate the qualities of the system. Analyze the benefits of the system, any drawbacks it may have, and its overall efficiency. Report your findings to the class.
6. Give one example of a device in a typical home that uses an open-loop system and one example that uses a closed-loop system. Draw a system diagram of each.
7. Construct a scale model of the floor and walls of one room in your home. Think of the furniture you would like to choose if the room were empty. Cut blocks of Styrofoam® or cardboard to represent the furniture. Be sure to use the same scale you used to create the room. Position the furniture in the room.

Apply Your Knowledge *(Continued)*

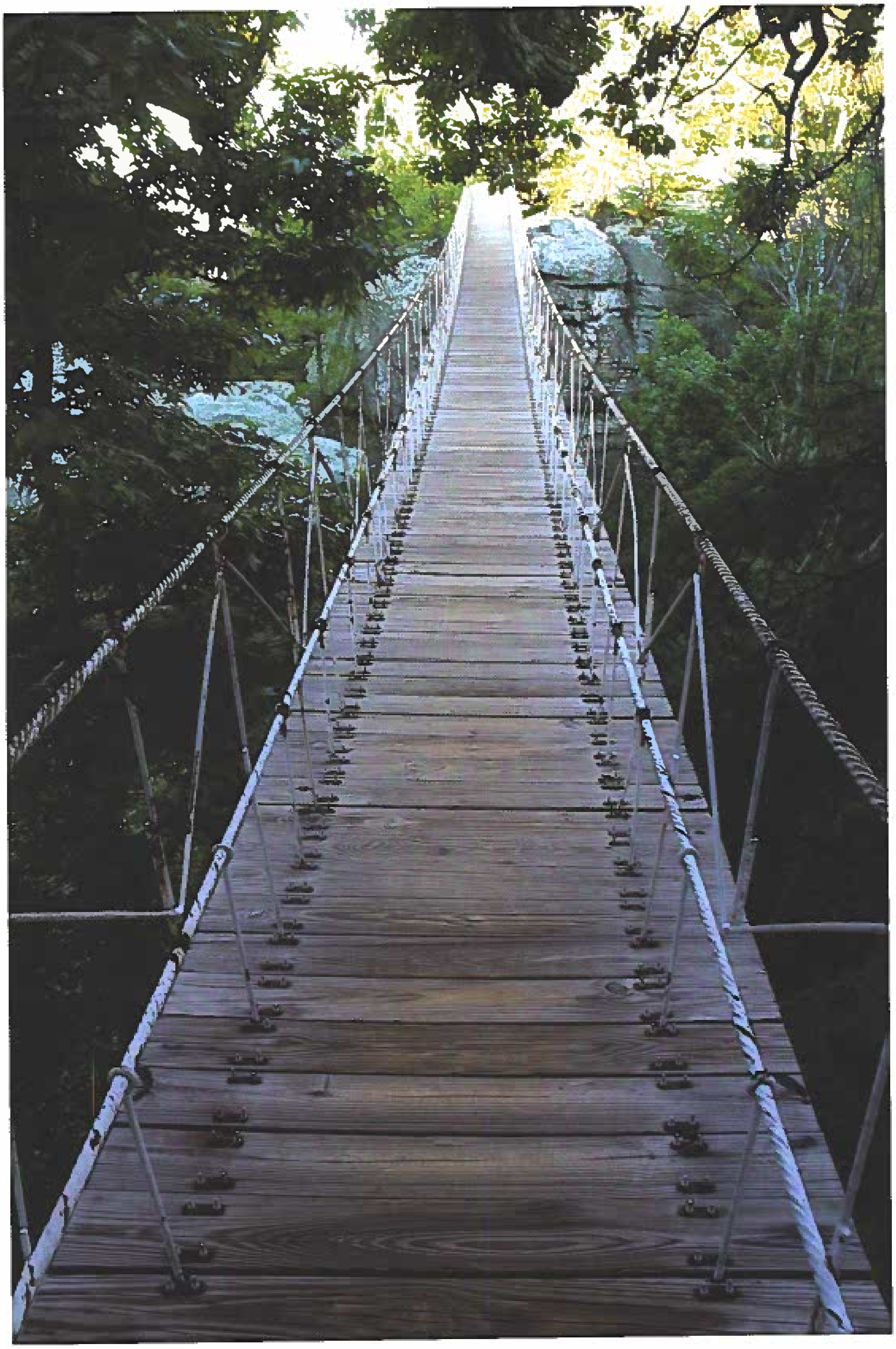
8. More and more new houses and apartments are "smart homes," loaded with appliances connected to the Internet. Which devices can be connected to a local network, and for what purpose?
9. Research one career related to the information you have studied in this chapter. Create a report that states the following:
   - The occupation you selected
   - The education requirements to enter this occupation
   - The possibilities for promotion to a higher level
   - What someone with this career does on a daily basis
   - The earning potential for someone with this career

   You might find this information on the Internet or in your library. If possible, interview a person who already works in this field to answer the five points. Finally, state why you might or might not be interested in pursuing this occupation when you finish school.

STEM Applications

1. **TECHNOLOGY** Make a list of common household devices that are not currently automated. Describe which of these might be automated in the future and how their function could be changed.
2. **ENGINEERING** Design a floor plan for a new home. The client wants a home with no more than 1700 square feet. She wants 3 bedrooms and two bathrooms. Design the home so that each room is large enough for its intended purpose. Label each room with its purpose (such as KITCHEN or BEDROOM) and the size of the room (such as 8′ × 12′). Check the total square footage of the house to make sure it is within the client's 1700-sq. ft. limit. Do not forget to include the square footage of hallways. Use graph paper or a CAD system to draw the floor plan after you have finalized the design.
3. **SCIENCE** One test that is commonly performed before a site is approved for building is a water (soil) percolation test. This test shows how well water drains from the soil. It is particularly important if the planned home will have a septic tank. The percolation rate depends on the type of soil. To determine which type of soil has the best percolation rate, collect samples of the following types of soil:
   - Sandy
   - Rocky/gravel
   - Clay

   Design a simple test to determine which type of soil drains water the fastest. Record the time it takes water to run through the soil and the amount of water that is retained by the soil. Document your test procedure and results in a lab notebook. Include an analysis of your findings.



Not all bridges are large structures. Smaller bridges, such as this footbridge, must also be designed for strength and safety. What materials did the designers use in this bridge? How is the bridge supported? Where would a bridge like this be appropriate?

CHAPTER 8

Machines

In this walk-behind lawn mower, the gas tank is placed with the engine for a more unified appearance.

Better by Design

Charles Harrison designs machines used around the home

Charles "Chuck" Harrison is one the most productive and respected American industrial designers of his time. He has been involved in the design of more than 750 consumer products that have improved the life of millions. Harrison helped design the portable hair dryer, toasters, stereos, lawn mowers, sewing machines, and the see-through measuring cup. He worked on power tools, fondue pots, and stoves. Among his most important designs was the first plastic garbage can. The tough plastic can was lighter and more durable than the traditional metal can. The round container evolved shortly into the familiar square green hulk with two wheels and raccoon-proof lid.

Harrison designed this hedge trimmer with plastic parts to minimize its weight.

"My best efforts resulted in products that did their job as expected—you look at it, right away guess what it is supposed to do, and that's exactly what it does."