17

Land Transportation Systems

Basic Concepts

- Identify the three different types of land transportation routes.
- Cite examples of the three types of pathways.
- List the different modes of land transportation.
- Name the different kinds of land vehicles.

Intermediate Concepts

- Discuss the importance of the wheel.
- Summarize the history of land transportation.
- Explain how diesel-electric locomotives function.

Advanced Concepts

- Create a graph showing the increases in the speed of vehicles over time.

The term *land transportation* includes all methods of transport in which the vehicles travel on or are supported by the earth. Such transport can be long distance, as between cities or coasts. It can also be short-distance travel, such as within a structure or between structures.

The History of Land Transportation

Centuries ago, movement from one place to another was a slow process. The only means of land transportation was by foot. Walking is a very limited mode of transportation. People from long ago could only travel as far as they could walk. They had no vehicles, so all cargo had to be carried in their hands or on their backs.

These early humans soon began to use the knowledge and resources available to improve transportation technology. The development of new transportation vehicles began to emerge. Through the use of the

Sledge: An early example of the modern sled, built using logs.

crude tools available at the time, early travelers created sledges. The ***sledges***, early examples of the modern sled, were built using logs. The early humans dragged sledges across the land. The sledges allowed for the transporting of resources, such as wood, stone, and wild game that was hunted for food.

The Development of Wheeled Vehicles

The invention that most drastically changed the history of transportation was the wheel. The wheel is the basis of almost all land transportation vehicles. It can also be found on vehicles used in other transportation environments, such as the airplane and space shuttle. The invention of the wheel took place in the Middle East, over 5000 years ago. With this advancement came wheeled vehicles drawn by horses and oxen. The first wheeled vehicles were simple carts that had either two or four wheels. The carts were used to move cargo. They were essential to the development of trade among civilizations. The next wheeled vehicle to be developed, the chariot, was also used between civilizations. The chariot was used for war, however, rather than trade. Carts and chariots continued to be innovated into wagons, coaches, and carriages. These wheeled vehicles were common modes of transport through most of the nineteenth century. See **Figure 17-1.**

The Development of Vehicle Power

As the vehicle itself was being innovated, so was the way it was being powered. Early humans pulled the first sledges and carts themselves. As people began to domesticate animals, such as horses, oxen, and donkeys,

Figure 17-1. The development of the wheel brought many advancements in land transportation. Horse-drawn vehicles, arising from the wheel's invention, were in common usage until the early 1900s. (Deere & Company)

the animals were given the task of pulling the vehicles. Animals were used until new technologies, such as the steam engine and the internal combustion engine, were invented. By the mid-1800s, major land transportation advancements were beginning to be developed. In 1830, the first scheduled passenger train began the American railroad era. By 1840, the first electric car had been built. In the 1890s, the first internal combustion engine was utilized. By the early 1900s, Henry Ford devised a method for mass-producing gasoline engine automobiles. See **Figure 17-2.** His method revolutionized the transportation industry by producing automobiles that were affordable to the average family.

As we look at the history of land transportation, we must appreciate it. Inventions like the wheel and cart may seem simple and unsophisticated today. We must remember that these advances were as revolutionary at the time as flying cars would be today. It is important to appreciate each transportation contribution and how it has expanded and matured our society.

The Development of Roadways

Roads are not a new concept. They have been built for thousands of years. The ancient Chinese, Egyptians, and Incas all built roads to connect their cities together. The roads began as paths used by wild animals, migrating people, and nomads. The Romans were the most sophisticated road builders. They built a large system of roads that connected various parts of their territory to Rome, their capital. The Romans, unlike most civilizations before them, built wide roads and paved them with layers of

Figure 17-2. Henry Ford was the first manufacturer to mass-produce automobiles using an assembly line. This was what his assembly line looked like in 1914, in Highland Park, Michigan. (Ford Motor Company)

Curricular Connection

Social Studies: Electric Automobiles

Today, when we see electric automobiles at auto shows and on television, we assume they are a breakthrough idea. While the technology used in the vehicles is state-of-the-art, the concept of electric automobiles has been around for over 100 years. Electric automobiles were actually produced before gasoline vehicles and had their height of glory in the late 1800s and early 1900s. Several people are credited to have built the first electric automobiles in the 1880s and 1890s, including William Morrison of Des Moines, Philip Pratt of Boston, and John Barrett of Philadelphia. Electric cars were even present at the World's Colombian Exhibition at Chicago in 1893. Over the next 10 to 15 years, electric automobiles became quite popular and competed with both steam and gasoline automobiles. By the end of the nineteenth century, electric automobiles had reached top speeds of over 60 miles per hour (mph), which was unheard of at the time.

Electric automobiles were used mainly in cities because rural areas had little, if any, access to electricity to recharge the batteries. One of the more popular uses was for taxicabs. By 1900, 90% of all taxis in New York City were electric. The popularity of electric automobiles ended, however, by the mid-1910s. The decline in electric automobiles is credited to several factors. The main reasons are that internal combustion engines were being greatly improved and the cost of gasoline was decreasing. Gasoline was also becoming more readily available than electricity. While gasoline engines eventually won the popularity race, the existence and performance of early electric automobiles should not be forgotten.

GREEN TECH
Manufacturers have once again been working to perfect electric cars. Hybrid vehicles operate on gasoline and electricity, but completely electric cars have not yet become as popular. Electric batteries are being improved in order to compete with gasoline and hybrid vehicles.

stones. Parts of some of the roads still exist today and are over 2000 years old. The methods of road construction varied little until the nineteenth century. Several engineers in the early 1800s developed new methods of constructing roads and began to use new materials. These methods are the framework that led to many of the advances in roadways today.

The development of roads was critical to the expansion of the United States. It is amazing how large of a role transportation has played in the settling of North America. Without roadways, we would not be as developed as we are today. It was the roads that enabled our founding fathers to continue on their journeys westward. Good roadways encouraged migration, which led to people settling throughout the country.

Today, the United States, as well as many other countries, has a complex system of local roads and highways. The local roads are used to travel within a town or city. Highways are used to travel between cities. The United States has a system of roads that connect most major cities, known as the interstate system. The interstate system, originally constructed to aid in national defense, is comprised of limited access highways that connect to each other. They are termed *limited access* because vehicles can only get on and off the highway at the on- and off-ramps. See **Figure 17-3.**

Technology Link

Construction: Road Construction

Construction technology is often viewed simply as the building of houses. There are, however, several other types of construction. One major area of construction technology is the building of roads and highways. Roads have been built for thousands of years, but in the last century, they have become technologically advanced. The construction of roads today relies on the expertise of engineers and the muscle of road-building construction equipment.

Asphalt roads and highways generally consist of several layers. The bottom layer is known as the subgrade. The leveling and compaction of the subgrade is the first process to take place in the construction of a roadway. The next layer of the roadway is the foundation layer. The foundation is designed and constructed so the center of the roadway is at a higher elevation than the sides of the road. Compactors are then used to compress the foundation. The next layer of the roadway is the surface course, which is typically an asphalt mixture. The asphalt is laid using pavers. Once the paver has laid the asphalt, a series of rollers is used to compress and smooth the final road.

The Development of Railroads

The first railway was developed in England in the sixteenth century. A railway is a road or pathway on which rails are placed. A train's wheels then roll on the rails. The first railways were used to carry heavy loads of cargo on small cars. They were operated by hand and went back and forth

Figure 17-3. Limited access highways, such as those making up the interstate system, permit entry and exit only at certain points. In some areas of the country, exits may be many miles apart.

Figure 17-4. The laying of the first cast-iron rails across a prairie was recorded in this historic photograph. (Burlington Northern Santa Fe)

on short runs in mines. The first rails were no more than narrow wooden strips. Later, rails of wrought iron were placed on the wooden base of the track. In 1767, the first cast-iron rails began to be used. See **Figure 17-4.**

In 1825, Colonel John Stevens of New Jersey built the first small locomotive, or self-propelled railcar, which was powered by steam. George Stephenson built the forerunner of what would become the standard steam engine in 1829. At that time, the locomotive proved itself as a means of motive power. It was then that railways became railroads. ***Railroads*** are permanent roads made of a line of tracks fixed to wooden or concrete ties. In 1869, a railroad track stretching from Omaha, Nebraska to Sacramento, California was constructed. See **Figure 17-5.** It was not long until other railroad companies linked onto this track. This rapid growth soon connected the eastern states with the West Coast. Business began to spread, and towns were established along the railroads. A country still in its early development stages began to grow into a great nation with the help of the railroads and the people who worked for the railroads. A modern railroad provides a track for heavy equipment, such as locomotives and rolling stock. Railroad cars pulled by the locomotive are called ***rolling stock***. Today, railroads are used for transporting large shipments of cargo over long distances.

Railroad: A permanent road made of a line of tracks fixed to wooden or concrete ties.

Figure 17-5. This photograph commemorates the laying of the last section of track that linked the East and the West. (Burlington Northern Santa Fe)

By the mid-1900s, most steam locomotives had been replaced by diesel-electric locomotives, named after the engine's inventor, Dr. Rudolph Diesel. The diesel-electric locomotives could travel faster and were more powerful and efficient. These locomotives use diesel engines to move large pistons in a generator. The generator converts the mechanical power into electrical power. The electrical power then turns electric motors, which turn the train wheels. Diesel locomotives are used around the world and produce much less air pollution than steam engines. With the use of diesel-electric power, the locomotives can pull upwards of 50–60 train cars. See **Figure 17-6.** By placing more than one locomotive at the front, the train could be even longer. This allows more freight to be transported than previously thought possible.

Figure 17-6. Several diesel-electric locomotives are often joined together to pull long strings of freight cars.

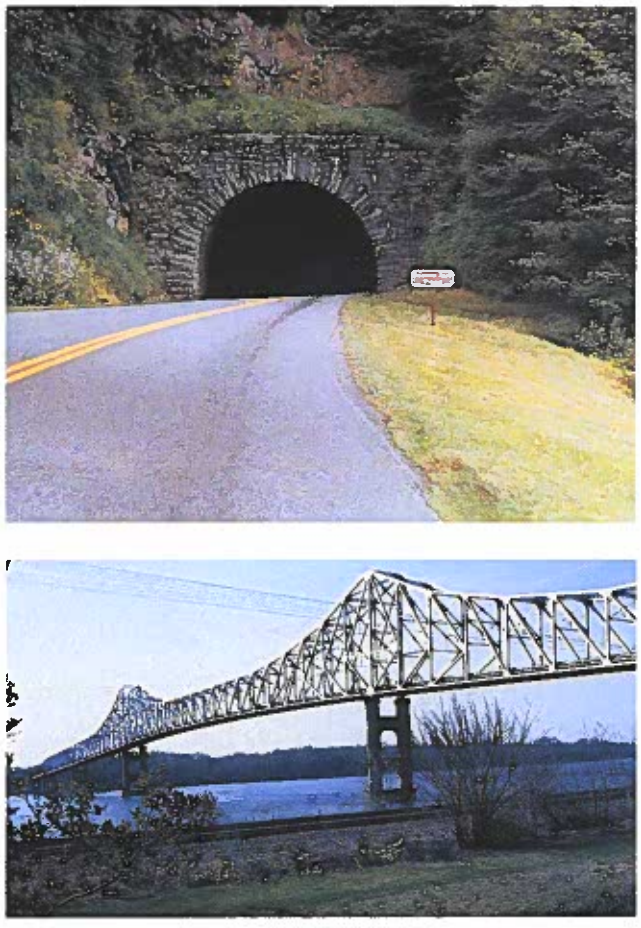
Rolling stock: A railroad car pulled by a locomotive.

Pathways

All land transportation vehicles travel on a pathway. These pathways are physical devices arranged in a system. The purpose of the pathways is to restrict the freedom of movement of the vehicles. There are three types of pathways: nonfixed, fixed, and stationary.

Pathways are developed to support vehicles. For instance, roadways and railways are used to support automobiles and trains. Through the use of pathways, vehicles are able to reach their destinations in a safe and efficient manner. Pathways allow natural barriers to be crossed. Mountains are tunneled, and rivers are bridged. See **Figure 17-7.** Pathways allow vehicles to move about on the land without hurting people or bringing damage to property. Our cities, towns, and rural areas would be very dangerous if we did not set aside space to be used as pathways for vehicles. We would not be safe walking or driving!

Figure 17-7. The problems of natural barriers are solved with the construction of tunnels and bridges.



Nonfixed Pathways

Automobile drivers are free to move their vehicles to the left and right. They are also free to go forward and backward. Automobiles have a lot of freedom of movement. The driver must stay on a road, but she usually has a

Nonfixed pathway: A pathway in which a vehicle has freedom to move in various directions.

choice of which road to take. When a vehicle has such freedom to move within a pathway, the pathway is identified as a ***nonfixed pathway***. The main advantages of nonfixed paths are that they best serve human needs and wants.

A disadvantage of nonfixed pathways is that they use excessive amounts of land. The building of roads often destroys a portion of our environment. Also, modes of transportation that use nonfixed pathways consume a lot of energy and cause air and noise pollution. Roads, highways, trails, and sidewalks are all examples of nonfixed pathways.

Fixed Pathways

Fixed pathway: A pathway that has a fixed route.

Stationary pathway: A transporting path in which the structure does not move.

A ***fixed pathway*** does not allow the driver of the vehicle the same freedoms as a nonfixed pathway does. A railway and a subway line are two examples of fixed pathways. See **Figure 17-8.** A train does not have the freedom to go wherever the operator wants. The driver must follow the track. Fixed pathways are not as destructive to our environment. Railroads, for example, do not require the same amount of land as a typical four-lane highway. The vehicles used in fixed pathways are often more efficient than nonfixed pathway vehicles, when you compare the amount of people and cargo they can haul. A disadvantage of a fixed pathway, however, is they are less responsive to meeting human desires. People and cargo are loaded and unloaded at terminals on the fixed pathway. These terminals may not be the final destination, and the cargo or people may then need to take different vehicles to their destinations.

Figure 17-8. A fixed pathway, such as this railway line, allows only linear movement.

Stationary Pathways

There is another type of transporting path called a ***stationary pathway***. The system may have moving internal elements, such as belts or chains, but the basic supporting structure is stationary. Stationary systems usually move goods.

Pipeline structures do not move. The pipe extends from the point where material enters the system to the point where material is discharged. The materials are moved through the system by the use of pressure, gravity, or vacuum.

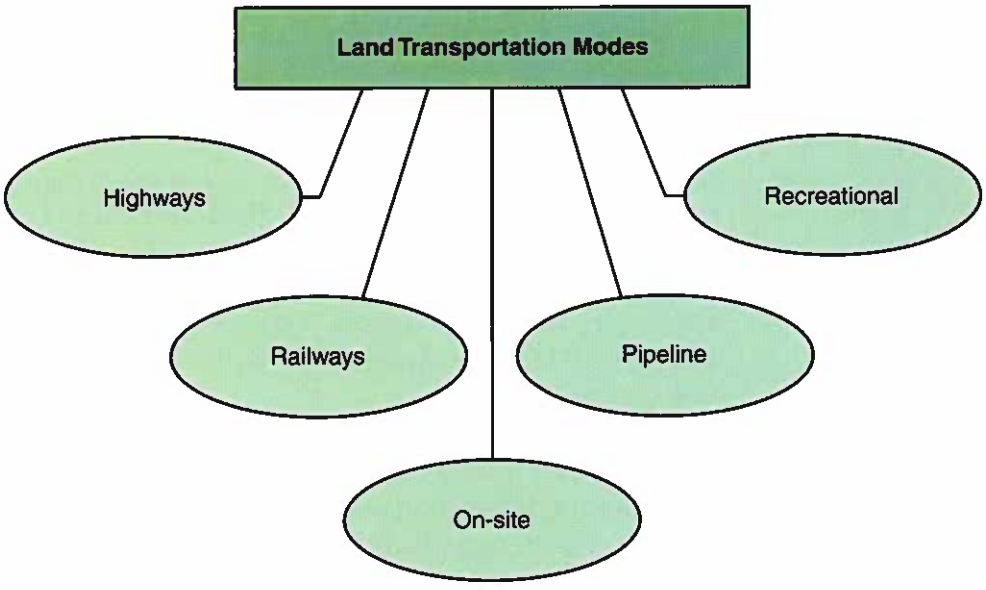
Conveyors are another example of the stationary system of transporting. They can be designed to move either people or goods. See **Figure 17-9.**

Modes of Land Transportation

Land transportation can be divided into several different modes of transportation. See **Figure 17-10.** Each mode of land

Figure 17-9. This complex conveyor system was built to move passenger baggage at DeGaulle International Airport in Paris, France. A conveyor system is a stationary pathway. (Siemens)

Figure 17-10. All land transportation can be placed in one of these five categories, or modes.



GREEN TECH
Some forms of recreational land transportation, such as bicycles, can also be applied to roadway transportation. To some people, this is preferred because there are no emissions and no fuel consumption.

transportation has a specific purpose and includes a number of different vehicles. These modes of transportation will be discussed in more detail within this chapter:

- **Highway land transportation.** This is transportation that occurs on roadways and highways.
- **Railway land transportation.** This is the movement of people and cargo in vehicles that use rails as guidance.
- **Pipeline land transportation.** This is the movement of cargo through stationary pipes.
- **On-site land transportation.** This is the transportation of people and cargo short distances within buildings and complexes.
- **Recreational land transportation.** This is transportation for fun, sport, and recreation.

Highway Land Transportation

Most of the land transportation we commonly use every day falls into the mode of highway land transportation. Whether you ride to school in a car or bus, you are using highway land transportation. Highway land transportation is the movement of people or cargo on roadways and highways. A roadway may be as simple as a dirt or gravel country road or as complex as an eight-lane superhighway. Each road serves a specific need in the land transportation system. Roads and highways make up an enormous part of our world. You need only to look at a road map to get an idea of the miles of highways that crisscross the landscape. Much of our travel would be impossible without these highways.

Figure 17-11. A two-cylinder, four-cycle engine powered Henry Ford's first car, which was invented in 1896. The car had an electric bell attached to the front to warn pedestrians.

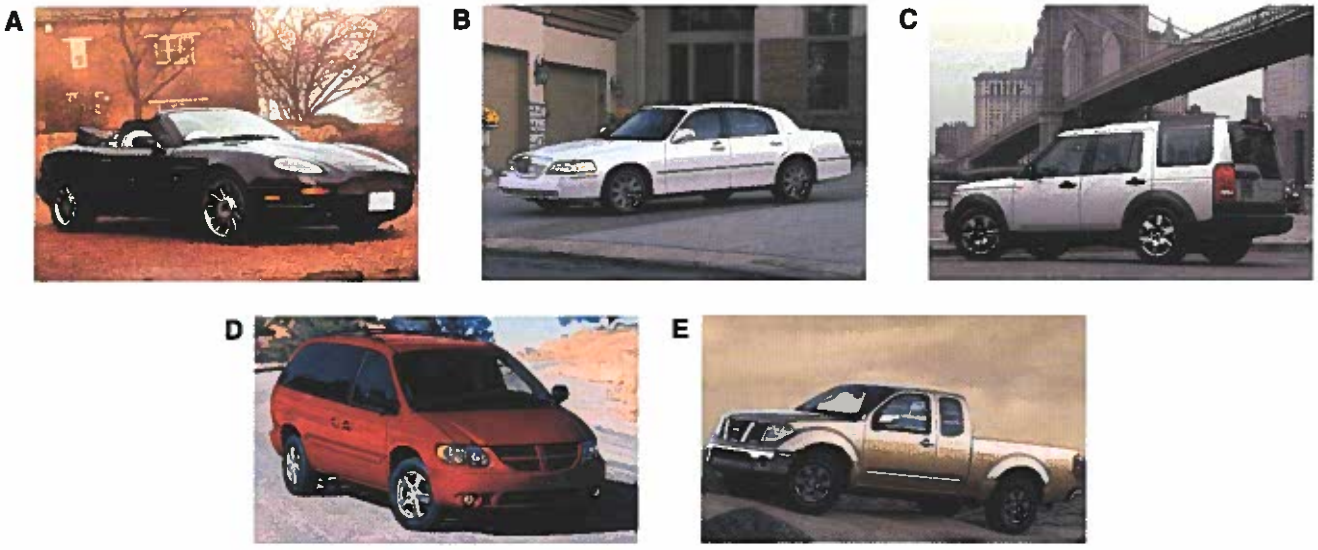
Automobiles

In the early twentieth century, the automobile was in developmental stages. See **Figure 17-11.** Ford made the automobile a common sight on early twentieth-century American roads. He made the automobile cheap, easy to operate, and easy to maintain.

The design of the automobile has changed immensely over the past 100 years. From a carriage-like, steam-powered buggy that did a maximum of 10 miles per hour (mph), the automobile has evolved into an aerodynamic turboengine sports car that can reach speeds up to 200 mph. Today, there are also a number of different styles of automobiles available. See **Figure 17-12.**

- *Coupes* are small, usually two-door, cars. Some coupes are often termed *sports cars*.
- Sedans are larger than coupes and have more interior room. They are typically found as four-door cars.
- Sport-utility vehicles (SUVs) are somewhat of a combination of sedans and pickups. They are raised, like pickups, and include many of the features and comforts you would find in a sedan.

Figure 17-12. Basic vehicle styles. A—A coupe. (Aston-Martin) B—A sedan. (Lincoln-Mercury) C—A sport-utility vehicle (SUV). (Land Rover) D—A van. (DaimlerChrysler) E—A light truck. (Nissan)



- Vans are built to hold more cargo and passengers than other automobiles. Minivans and conversion vans are configured to hold passengers and designed for family use. Cargo, or panel, vans are built to carry cargo.
- Light (or pickup) trucks sit taller than most other automobiles and have an open bed to transport cargo.

Coupe: A small, usually two-door, car.

While we have shaped the automobile, it has also shaped our communities. Certainly our neighborhoods would be much different from how they are today if there were no automobiles. See **Figure 17-13.**

Figure 17-13. These pictures show how much the automobile has changed our society.

Trucks

Straight truck: A truck that has one frame that connects both the front and rear axles.

Trucks can be divided into three main types: light, medium-duty, and heavy-duty. Light trucks, or pickups, were discussed in the automobile section because they are manufactured, marketed, and sold like automobiles. They are most often used for passenger transportation. Medium- and heavy-duty trucks are used for the transportation of cargo. Medium-duty trucks are configured in a straight truck design. ***Straight trucks*** have one frame that connects both the front and rear axles. The beds of medium-duty trucks are built to fit the needs of the user. Medium-duty trucks are made into delivery trucks, garbage trucks, dump trucks, tank trucks, tow trucks, and recreational vehicles, just by changing the type of bed. See **Figure 17-14.** Heavy-duty trucks are also known as tractor-trailers. These are usually seen on the highways and are called *18-wheelers*, or *semis*. Tractor-trailers are used to carry freight between cities. The tractor is the front part of the truck that houses the engine. It is powered by a diesel engine, rather than a gasoline engine. The reason for this is

Figure 17-14. Medium-duty trucks are offered in many different configurations. A—A television station remote broadcast vehicle. B—A refuse hauler. (Mercedes-Benz) C—A concrete mixer. (Mercedes-Benz) D—A dump truck. (Mack Truck Company)

that more power is available for the hauling of heavy freight. The trailer is the back end of the truck. Some trailers are tanks that haul liquid or gas. See **Figure 17-15.** Other trailers are boxlike. They are used for hauling grain, livestock, or packaged goods from manufacturing companies. There are also refrigerator trucks used to transport food products. The trailers are made of lighter metals to reduce the overall weight of the truck. This allows them to carry more cargo. Federal and state governments have regulations that limit the length and weight of the trucks and their cargo.

Figure 17-15. Semitractors haul different types of freight. This one is hauling a tanker loaded with a liquid cargo.

Career Connection

Truck Drivers

Transportation, Distribution & Logistics

Our nation relies on the transportation of goods. Most of the movement of goods within the nation uses highway transportation, and a large amount of goods are moved by tractor-trailer. Without drivers, the goods would never get to their destinations. There are two main types of truck drivers: tractor-trailer drivers and delivery service truck drivers.

Tractor-trailer drivers drive goods from city to city and often across the nation. They often have routes that keep them on the road for days at a time. The average earnings for a tractor-trailer driver equal about $17 per hour. Delivery truck drivers often have daily routes that allow them to be home every night. They deliver goods within cities or to nearby cities in straight trucks or vans. Many of these drivers are stationed at a base and deliver goods to and from the base. The average earnings for a delivery truck driver equal about $13.50 per hour.

The main qualification for all truck drivers is that they must have a commercial driver's license (CDL). The CDL is obtained from the state in which the driver is based. CDLs require drivers to be 18 years old and to take a written test and a driving test. To drive across state lines, the Federal Motor Carrier Safety Administration (FMCSA) regulations require a number of health, vision, and hearing levels, and drivers must be 21 years of age. Most trucking companies require drivers to have a high school diploma, and some look for graduation from a commercial driving school.

GREEN TECH
The use of public transportation, such as buses or trains, is considered more environmentally friendly because of the decreased air pollution. Another environmentally friendly option is carpooling. This helps consume less fuel per person and reduces emissions.

An advantage of moving cargo by truck is a reduction in damage to the cargo. Cargo travels more safely in a truck. Packaging is not considered a necessity. Therefore, this saves on the cost of containers. It also saves on the packing material. Trucks are loaded with freight at trucking terminals or warehouses. See **Figure 17-16.** A supervisor checks the loaded freight. Once all information about the load is gathered, the truck is ready to roll on to its destination. In the United States, operation and safety standards are set and regulated by the Federal Motor Carrier Safety Administration (FMCSA), which is a division of the Department of Transportation. A great advantage of the truck, as opposed to any other form of carrier, is its flexibility. It is convenient for a truck to transport products from door to door quickly.

Buses

The first use of the bus was to extend railroad lines. When the tracks ended, a bus would continue transporting people into the city. Bus lines were soon established for crosstown transportation where there were no tracks. Buses also were needed for the transportation of school children. See **Figure 17-17.** These vehicles are a necessity today in school systems. Buses bring rural and suburban children into the cities.

One of the major advantages of a bus is that it can haul many passengers at once. Another advantage is that it has frequent pickup and delivery points for the passengers. Many people feel, however, that the advantages of the automobile are not worth the trade-offs involved in riding a bus. A bus rider would have to trade some convenience and comfort for decreased air pollution and traffic congestion. Bus companies

Figure 17-16. Pallet loads of freight are loaded aboard trucks at warehouses or trucking terminals. Sometimes, a truck will pick up a full load at one location. At other times, smaller quantities of cargo will be loaded at several different locations.

need to consider the scheduling, routing, comfort, and frequency of the bus service. See **Figure 17-18.** Buses must meet the needs of the people, or people will not ride them.

Motorcycles

Motorcycles are another kind of land transportation vehicle. These vehicles are often seen on the highways and streets. Police departments, delivery services, and pleasure riders use them. See **Figure 17-19.** The first successful motorcycle had an internal combustion engine mounted on a three-wheeled bicycle. Today, three-wheeled motorcycles, or trikes, are not as common as two-wheeled motorcycles. Motorcycles can be categorized into two different groups: street and off-road motorcycles. Street motorcycle styles include cruiser, sport, touring, and standard. Many people today travel on motorcycles across the country. The design of the motorcycle has changed to meet the personal needs and preferences of the operator and passenger.

Figure 17-17. Many children travel to school on buses.

Heavy equipment

Many land transportation vehicles are designed for specific purposes other than just moving people or cargo. ***Heavy equipment*** includes large and powerful vehicles used for reasons such as moving earth, farming fields, and conducting warfare. It can be organized into construction, farming, and military equipment. Construction equipment, including bulldozers, paving machines, and wheeled cranes, is used in the building of everything from roads and bridges to homes. See **Figure 17-20.** Farm equipment, such as tractors, is used in the planting, growing, and harvesting of crops. See **Figure 17-21.** Military equipment, including personnel carriers, surveillance vehicles, jeeps, tanks, and other armored fighting vehicles, is the last type of heavy equipment land vehicle. See **Figure 17-22.**

Heavy equipment: A large and powerful vehicle used for reasons such as moving earth, farming fields, and conducting warfare.

Figure 17-18. The bus industry competes with automobiles in the transporting of people. This is a local bus operating in the Netherlands, picking up passengers for the town of Haarlem. (Van Hool)

Rail Land Transportation

Railway lines form a network of tracks across the country. Railroads have been a factor in moving people and cargo for more than 300 years. A railroad system consists of the following elements:

- Miles of roadbed and rails strong enough to carry the heavy weight of the trains and their payloads.
- A system of signal devices so movement of trains on the same track can be safely coordinated.
- A variety of engines to pull the trains.

Figure 17-19. Orange County Choppers, a specialty firm that builds custom motorcycles, created this commemorative motorcycle for the Miller Electric Manufacturing Company. This motorcycle was commissioned to celebrate the 75th anniversary of the company, a major manufacturer of welding equipment. (Miller Electric Manufacturing Company)

Figure 17-20. Paving machines lay down a lanewide ribbon of asphalt in a single pass. Several layers are normally used for roads or parking areas. (Terex/Cedarapids)

- Cars designed for carrying passengers or a variety of different products and materials.
- Stations for loading and unloading passengers and handling cargo (freight).

Rail transportation systems offer services for the transporting of both freight and passengers.

Freight trains

A ***freight train*** is several freight cars joined together and pulled by an engine or locomotive. Several different types of freight cars are used to transport different types of cargo. See **Figure 17-23.** ***Boxcars*** are boxlike cars with doors on both sides. They may be refrigerated to carry frozen foods or any other product that must be kept cool. ***Flatcars*** are sturdy platforms on wheels. They carry such material as steel, lumber, truck trailers, containers, and even very heavy equipment. ***Gondolas*** have high or low sides with no tops. They transport loose material, such as stone, scrap metal, and iron. ***Hopper cars*** have hoppers (chutes) underneath. They carry bulk materials, such as coal and ore. Closed hoppers are used to haul materials that need to be protected from the weather, such as corn, wheat, sand, salt, and fertilizer. ***Tank cars*** are large tanks on wheels. They transport liquids. ***Transport cars*** are flatcars with side rails. They are mainly used for transporting new automobiles and trucks from manufacturing plants to car dealers. A ***caboose*** is the last car on the freight train. It is used to house the train crew.

Most freight trains are made up of a combination of cars carrying different cargo. The cars may have a number of different stops before they reach their final destinations. A unit train is not like a typical freight train. ***Unit trains*** carry only one type of cargo, and all of its cars are alike. See **Figure 17-24.** A unit train goes to the same destination trip after trip.

It is more economical to haul large amounts of cargo by railroad than by highway. Carrying freight by railroad also has fewer restrictions on the weight and size of the cargo, as mandated by the Federal Railroad Administration (FRA). Highway regulations place limits on the weight and length of the loads trucks can carry.

Figure 17-21. The modern tractor makes plowing, planting, cultivating, and harvesting much more efficient. (Howard Bud Smith)

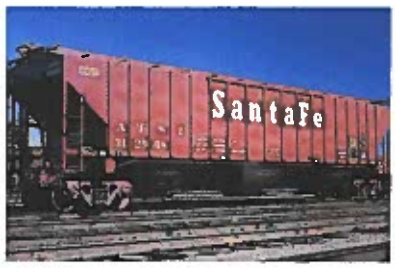
Figure 17-22. The Humvee military vehicle can be configured many different ways to perform different tasks. This one is being used to guard a traffic checkpoint. (U.S. Army)

Freight train: Several freight cars joined together and pulled by an engine or locomotive.

Boxcar: A boxlike freight car with doors on both sides.

Figure 17-23. Some common types of railway cars. A—A boxcar has large doors and a high roof to transport general cargo. B—A hopper car is designed to haul loose bulk, such as coal and grain. C—A flatcar is used to carry large machines or to "piggyback" semitrailers. (Burlington Northern Santa Fe)

A 

B 

C 

Flatcar: A freight car that is a sturdy platform on wheels. It carries steel, lumber, truck trailers, containers, and heavy equipment.

Gondola: A freight car that has high or low sides with no tops. It transports loose material.

Hopper car: A freight car with chutes underneath. It carries bulk materials.

Tank car: A freight car that is a large tank on wheels for transporting liquids.

Transport car: A flatcar with side rails. It is mainly used for transporting new vehicles from manufacturing plants to car dealers.

Caboose: The last car on a freight train. It is used to house the train crew.

Figure 17-24. Unit trains transport only one product, such as coal.

Passenger trains

Passenger trains are trains that transport people. This form of transportation causes little traffic congestion and is safer than some other forms of transportation. There are two main types of passenger trains: long-distance rail and mass transit rail.

Long-distance rail transportation is used when passengers want to travel between distant cities on a train. One advantage of this type of transportation is that the passengers can sit back and relax on the trip because they do not have to drive the vehicle. The railroad is also often a more direct route to the destination than the highway. Long-distance passenger trains are not as convenient, however, as automobiles. Riding a train reduces schedule flexibility. Amtrak is the largest long-distance passenger train in the United States. It transports people from city to city across the United States. See **Figure 17-25.**

Mass transit rail systems are a form of rail transportation that can carry many people at one time. They transport people shorter distances, often between work and home. There are three main types of mass transit rail systems: light-rail, heavy-rail, and high-speed rail. Light-rail systems can be used in intercity (between two cities) or intracity (within a city)

transportation. Heavy-rail systems typically carry more passengers and have larger trains than light-rail systems. A ***subway*** is a heavy-rail train that runs on a rail below the earth's surface. Another heavy-rail vehicle is an ***elevated train***, which is a rail system that runs above the city streets. See **Figure 17-26.** A ***monorail*** is a train that runs on a single rail. High-speed rail systems are used to connect two or more cities together. One fast electric, high-speed train is the French TGV (*train à grande vitesse*, or high-speed train), which hit a top speed of 322 mph. See **Figure 17-27.** The newest development in high-speed rail systems is the application of electromagnetism. ***Magnetic levitation (maglev)*** trains use powerful magnets to hover above and propel down the track. See **Figure 17-28.**

Unit train: A train that carries only one type of cargo.

Mass transit rail: A form of rail transportation that can carry many people at one time.

Figure 17-25. Amtrak operates trains for long-distance travel across the United States. It replaced passenger operations run by individual railroads. (Amtrak)

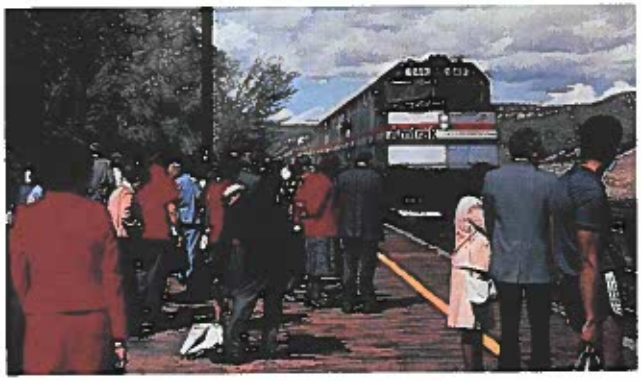


Figure 17-26. The "El" is Chicago's elevated railway system, which encircles the downtown area one story above the street. Although these systems can be used with light-rail vehicles, it is more common to use heavy-rail trains. Note the massive beams supporting the rail structure.

Figure 17-27. France's electric TGV (*train à grande vitesse*, or high-speed train), operates at speeds well in excess of 200 miles per hour (mph). High-speed rail tracks must be built further apart than traditional tracks because of the turbulence when trains pass each other. They must also have fences on each side of the track to ensure that animals and debris do not enter the track area.

Subway: A heavy-rail train that runs on a rail below the earth's surface.

Elevated train: A heavy-rail system that runs above the city streets.

Monorail: A train that runs on a single rail.

Magnetic levitation (maglev): A train that uses powerful magnets to hover above and propel down a track.

Figure 17-28. Magnetic levitation (maglev) trains transport passengers at high speeds in a number of countries. This train is on the outskirts of Shanghai, China. Since maglev trains do not actually touch the track, there is no friction to slow them. Several maglev rail systems are planned for the United States. (Transrapid International, Inc., GmbH)

GREEN TECH
Pipelines that transport oil have been known to pose some danger to the environment. If not constructed properly, there is a greater risk of oil spills. Oil spills can pollute land and water, as well as harm animals in those ecosystems.

Underwater rail systems

The Channel Tunnel project, also called the "Chunnel," is an underwater rail system linking Britain and France. For nearly 180 years, the idea of tunneling under the English Channel has been contemplated several times. This rail system consists of three tubes. Two tubes, 25′ in diameter, are linked at several points to a third tube about 16′ (4.8 m) in diameter. The smaller tube serves as a service tunnel. The two larger tunnels serve as the rail lines. One is for a westbound train, and the other is for an eastbound train. The third, center, tunnel is a service tunnel. The tubes, or tunnels, are 150 meters below sea level. Tunnel workers had to bore through chalk marl, which is the lowest layer of chalk under the channel. The tunnels were excavated using a boring machine. See **Figure 17-29.** The trains are able to carry passengers and cargo under the English Channel in 20 minutes. Electric locomotives drive these trains. See **Figure 17-30.**

Pipeline Transportation

The most efficient way to transport water from your house to a garden 100′ away would be to use a hose. This same efficiency would apply when transporting any product by pipeline. See **Figure 17-31.**

Centuries ago, pipelines were developed from bamboo. Water was transported through the hollow bamboo. Water-carrying pipelines were also made out of logs. The logs were hollowed out and fitted together. Being somewhat porous, the bamboo and the wood could not withstand the pressure of the water. Thus, by the late 1800s, iron pipelines were

Figure 17-29. Tunnel boring beneath the English Channel. A—Working 328′(100 m) below sea level, a boring machine is excavating a tunnel 25′ (7.6 m) in diameter. B—The rail has been installed for one of the tunnels. (Eurotunnel)

A

B

being constructed. Today, pipelines are made from steel or plastic and vary in diameter. One of the major pipelines you may be familiar with was constructed both above and below ground. This installation, known as the Trans-Alaska Pipeline, was constructed in 1977. It transports oil 775 miles across Alaska.

Pipelines are used to transport such products as oil, natural gas, water, coal, and gravel. Some of these substances are fluid and flow easily through a pipe. Others need to be mixed into a liquid solution called slurry, in order to be transported by a pipeline. ***Slurry*** is a mixture of a ground solid, such as coal, along with a liquid, such as water.

Pipeline construction

Construction of pipelines requires careful planning. Once a company decides to construct a pipeline, the route is first planned. The company will then contact the owners of the land where the pipeline will be constructed. Once an agreement is reached with the landowners, the path the pipeline will follow is cleared. The pipes are then laid out along the path. The digging or trenching of the earth begins. See **Figure 17-32.** Pipe is laid in the trench and welded together. The welds are examined visually and inspected using X-ray

Figure 17-30. The Channel Tunnel train pulls cars loaded with cargo and passengers. (Eurotunnel)

Figure 17-31. Pipelines stretch across many miles and carry several different kinds of materials. (The Coastal Corporation)

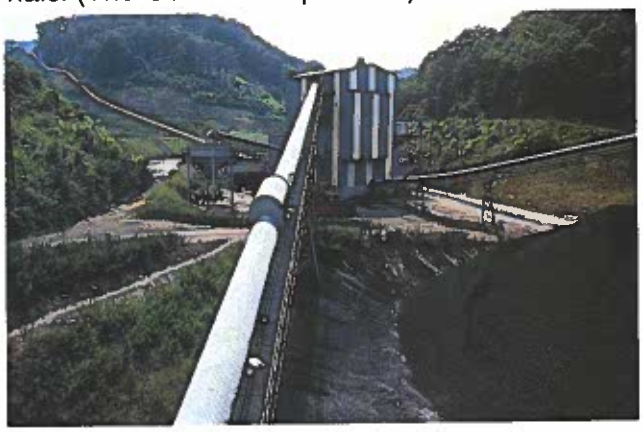


Figure 17-32. It takes many workers and machines to lay a pipeline. (The Coastal Corporation)

machines to ensure there will be no leaks. If the pipe passes the inspection, the trench is then refilled with earth. At this point, the pipeline is out of sight, and the earth is returned to its original condition.

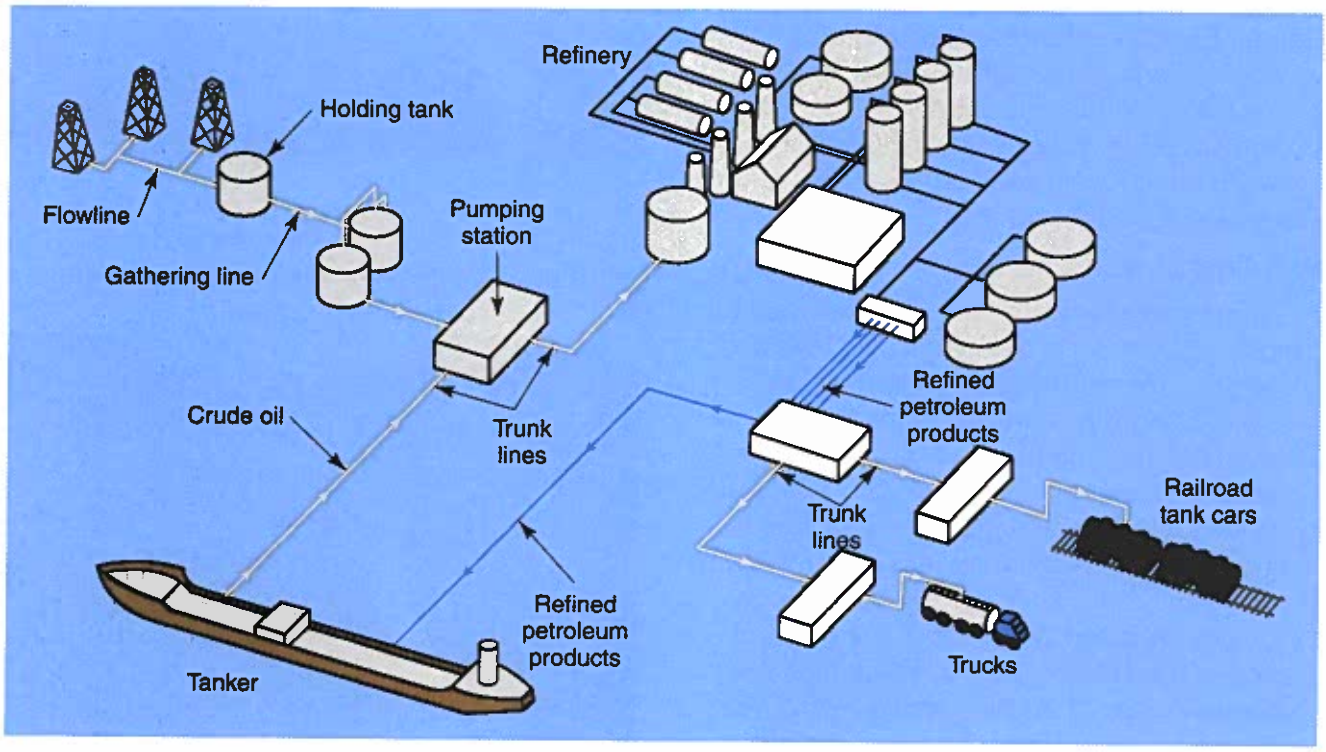
Pipeline operation

A pipeline is a system of different types and sizes of pipes. See **Figure 17-33.** Each pipe has a specific task in the system. At the beginning of the process, the product to be transported is collected and stored. The pipes used at this stage are known as flow lines and ***gathering lines***. The product is pumped from its source to a processing facility or storage tank using the flow or gathering lines. These lines can be from 2–12″ in diameter. From the processing and storage facilities, the products are transported to the main line using feeder lines. The feeder lines are larger in diameter, up to 20″, because they typically carry more cargo than the flow and gathering lines. A number of feeder lines are pumped into the main lines, known as ***transmission lines***. These lines are the pipes that transport the cargo over great distances. The pipes are often buried and can be as large as 48″ in diameter. The transmission lines are routed to different places, depending on the product the pipeline serves. Once the products have reached their

Slurry: A mixture of a ground solid and a liquid.

Gathering line: A pipe in a pipeline system in which the product to be transported is collected and stored.

Figure 17-33. An oil pipeline system moves crude oil to the refinery and then moves petroleum products to storage or to transport systems that will move them wherever they are to be used.



distribution centers, smaller pipelines, known as distribution lines, are used to transport the products to their final destinations.

To prevent pipeline clogging, a barrel-shaped brush, known as a ***pig***, routinely cleans the line. The pig can be blown through the line or pushed through with moving cargo. Smart pigs, or electronic pigs, can be used to determine the condition of the pipelines. They are able to detect cracks and leaks from inside the pipeline.

Several different products can be transported through the same pipeline. Products are simply pumped into the pipeline in separate batches. A batch of gasoline may be followed by diesel fuel or kerosene. This is called a ***batch sequence***. Once the batches reach the terminals, they are separated by weight with a computerized device called a ***gravitometer***. Each product is pumped into its respective holding tanks and is ready for distribution.

Transmission line: A pipe in a pipeline system that transports cargo over great distances.

Pig: A barrel-shaped brush used to clean pipelines.

Batch sequence: An order of succession of the quantity of material prepared for one operation.

Gravitometer: A computerized device that separates products by weight.

On-Site Transportation

Highway, rail, and pipeline transportation typically deal with moving people or cargo a significant distance. The distance may be across town or even across the country or continent. There is a great amount of transportation, however, that occurs on a much smaller scale. Many times, people and cargo simply need to be transported up one story in a building or to the other side of a warehouse. This type of transportation is known as on-site transportation. It can be divided into two types: material handling and people moving.

Material-handling devices are vehicles used to transport cargo within buildings and complexes. They can be as simple as hand trucks or as complex as cranes and conveyor systems. Hand trucks are *L*-shaped vehicles with two wheels. Materials are loaded on the truck, and the truck is moved using human power. Conveyors are common material-handling devices. They are often used to transport products in manufacturing settings. Belt conveyors and roller conveyors are used to transport products down an assembly line. Trolley conveyors are still another method used to transport. A trolley conveyor moves overhead on a cable, as it lifts and transports products. Cargo is often placed on pallets to help in the handling of the products. The pallets are wooden platforms with openings that allow the arms of a forklift underneath. Forklifts are vehicles that can lift pallets and move them to new locations within a warehouse or building. See **Figure 17-34.**

Figure 17-34. A forklift can move heavy pallet loads of goods from place to place and store them in stacks or in special shelving-type racks. Operator skill is important to prevent damage to the materials or storage racks.

Figure 17-35. An escalator is a people transporter designed to move people between floors in buildings. It is a type of on-site transportation.

The most popular people-moving vehicle, the elevator, was invented as a material-handling device. Lifting devices have been used to move materials for thousands of years. These devices evolved into material-moving elevators. It was not until Elisha Otis invented the safety brake in 1854 that the elevator was used to move people. Today, elevators are common people movers in public buildings and even some homes. Other people movers include escalators and moving sidewalks. See **Figure 17-35.** Both of these vehicles can be found in public areas, such as shopping malls and airports.

Recreational Land Transportation

Land transportation can also be used for fun and exercise. Vehicles used for these purposes are in the recreational category of land transportation. Bicycles may be the most popular recreational land vehicles. There are four main types of bicycles: road, mountain, dirt, and recumbent. Recumbent bikes are the newest and most unique bicycles. Riders of recumbent bicycles sit in a more "seated" position, with the pedals in front of the rider. Other recreational land vehicles include mopeds, unicycles, dirt bikes, snowmobiles, skateboards, and scooters. See **Figure 17-36.** Keep in mind that the universal systems model is at work in recreational transportation. You will find inputs, processes, outputs, and feedback.

Figure 17-36. Recreational land transportation vehicles. A—Segway personal transporters can be used on or off paved surfaces and operate for several hours on a single electrical charging. (Segway Corporation) B—A recumbent bicycle is a relaxed form of transportation. C—Snowmobiles are popular for recreational use in cold climates. (Polaris)

A

B

C

Summary

Land transportation is a key element in our lives. Without it, we would not be as advanced as we are today. Transportation modes on land are highways, railways, pipelines, on-site, and recreational. The wheel was the beginning of many technological advancements in land transportation. It helped lead to the invention of the bicycle, car, truck, and bus.

The development of railroads assisted in the settlement of the West. Much freight is transported by train. In the inner city, mass transit is highly effective. Light-rail trains, subways, elevated trains, and monorails are all used daily in metropolitan areas to transport hundreds of people.

Pipelines are a unique form of transporting cargo. Liquid materials, such as oil, kerosene, and water, move by pipeline over several hundreds of miles. Solid bulk material, such as coal, copper, and gravel, can also be transported by pipeline when mixed with a liquid to form a slurry. Other transporting devices located in buildings help move people and products. Elevators, escalators, moving sidewalks, and conveyors are a few of these devices.

Key Words

All the following words have been used in this chapter. Do you know their meanings?

batch sequence
boxcar
caboose
coupe
elevated train
fixed pathway
flatcar
freight train
gathering line
gondola
gravitometer
heavy equipment
hopper car
magnetic levitation (maglev)
mass transit rail
monorail
nonfixed pathway
pig
railroad
rolling stock
sledge
slurry
stationary pathway
straight truck
subway
tank car
transmission line
transport car
unit train

Test Your Knowledge

Write your answers on a separate sheet of paper. Do not write in this book.

1. In what way has the wheel benefited land transportation?
2. *True or False?* Chariots were the first land vehicles.
3. *True or False?* Powered land transportation has always existed.
4. *True or False?* Roadways have been around for thousands of years.

5. *True or False?* Rolling stock is a name referring to any wheeled vehicle.
6. Describe how diesel-electric locomotives work.
7. List and describe two types of routes for land transportation vehicles.

Matching questions: For Questions 8 through 12, match the words on the left with the correct term on the right.

8. Roads.
9. Railroads.
10. Conveyors.
11. Sidewalks.
12. Pipelines.

A. Fixed pathways.
B. Nonfixed pathways.
C. Stationary pathways.

13. State the five modes of land transportation.
14. How has the invention of the automobile made life easier?

Matching questions: For Questions 15 through 18, match the phrases on the left with the correct term on the right.

15. Usually small, "sporty" cars.
16. Typically a four-door car.
17. Raised like a pickup, with features of a sedan.
18. Can be configured for cargo or passengers.

A. Coupe.
B. Sedan.
C. Sport-utility vehicle (SUV).
D. Van.

19. Name the three main types of trucks.
20. How is a straight truck different from a tractor-trailer?
21. *True or False?* The Federal Motor Carrier Safety Administration (FMCSA) oversees pipeline transportation.
22. Write four examples of highway land transportation vehicles.
23. Cite two types of street motorcycles.
24. A train car, with high or low sides and an open top, used for transporting material such as scrap metal, iron, and stone is called a:
    A. boxcar.
    B. gondola.
    C. flatcar.
25. What is a unit train?
26. *True or False?* Mass transit rail systems carry few people.

27. An elevated train is a rail system:
    A. below the city.
    B. through the city.
    C. above the city streets.
28. Define *slurry*.
29. What device is used to unclog a clogged pipeline?
30. *True or False?* Material-handling devices are used to transport cargo within a building or complex.

STEM Activities

1. Research the development of an early land transport vehicle and write a report on its development and use. Suggest what its impact was on society. As part of the report, suggest why it would or would not answer modern-day transportation needs.
2. Build an appearance model (one that looks like the original, but does not operate) of the vehicle you researched for Activity 1.
3. Imagine your community 50 years from now has all automobile traffic banned within the limits of the community. (If you do not live in a town or city, select a neighboring community.) Only delivery trucks and garbage trucks can enter the city. Design a system that will transport people to and from the community limits and determine which would be least polluting.

Career Skills

Leadership

All careers require leadership skills. Leadership is the ability to guide and motivate others to complete tasks or achieve goals. It involves communicating well with others, accepting responsibility, and making decisions with confidence. Those employees with leadership skills are most likely to be promoted to higher levels.

Leaders often seem to carry the most responsibility of a group. Other group members look to them for answers and direction. The most important role of leaders is to keep the team advancing toward its goal. Leaders do this by inspiring their groups and providing the motivation to keep everyone working together.

Good leaders encourage teamwork, because a team that is working together well is more likely to reach goals. They listen to the opinions of others and make sure all team members are included in projects. Leaders also want to set a good example by doing a fair share of the work. In these ways, leaders cultivate a sense of harmony in the group.

Leading others may not be easy for some people, but everyone can improve their leadership skills with practice. Becoming involved in a school club or organization can help. Taking a role as an officer or a committee chair will give you even more practice.