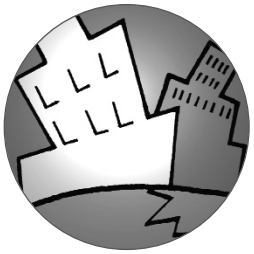


Earthquakes

Background

American Red Cross

Visit the American Red Cross Web site at *www.redcross.org/disaster/masters*

Earthquakes

The activities and information in *Masters of Disaster's Earthquakes* can help young people develop the skills needed to prepare for and stay safe during and after an earthquake.

These activities are specifically tailored for children in lower elementary (K–2), upper elementary (3–5) and middle school (6–8) grades. *Earthquakes* is divided into two sections, Earthquake Science and Earthquake Safety, including Tsunami Science and Safety.

***Masters of Disaster* Connections**

Refer to the following modules in the *Masters of Disaster* series to learn more about a particular topic and to reinforce the objectives of the lesson.

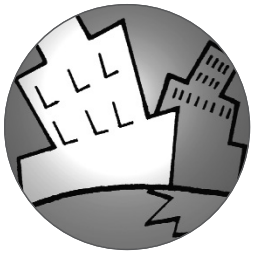
- Knowing how to prevent fire is vitally important to children and families because so many children are injured each year by fire. To complete the lessons on home safety, use the *Fire Prevention and Safety* module.
- An essential part of preparing for any disaster is to be ready with plans, supplies and practice. *Be Disaster Safe* inspires young people by teaching them to prepare for all hazards.
- The lessons of *In the Aftermath* focus on recovery after a disaster—for the individual, the school and the community.

Note: Another excellent resource for the classroom, and one used as a valuable reference in creating these materials, is Tremor Troops—produced by the Federal Emergency Management Agency and National Science Teachers Association. (*http://www.fema.gov/pdf/library/tremortroop.pdf*)

Why Talk About Earthquakes?

Earthquakes occur all the time, more than a million a year. While they tend to be concentrated in particular areas of the world, they can occur in many places. Most are so minor they go unnoticed. However, major earthquakes cause deaths, injuries and extensive property damage, particularly when they occur in highly populated areas. Like earthquakes, tsunamis and volcanoes are directly or indirectly caused by movement of the earth's tectonic plates, and often are interrelated. An earthquake can cause a tsunami, and volcanoes can cause both earthquakes and tsunamis. These geologic events can be devastating; understanding the science and safety is vital in preventing death and destruction.

Approximately 70 to 75 damaging earthquakes occur every year throughout the world. Some are so powerful they can be felt hundreds of miles from their epicenters, or that part of the earth directly above the focus of the quake. One series of earthquakes—among the strongest ever



Earthquakes

Background

experienced in the lower 48 United States—struck in 1811 and 1812 along the New Madrid fault in the central Mississippi Valley. These earthquakes were felt over most of the continental United States and as far away as Quebec. They were so powerful that they changed the course of the Mississippi River and rang church bells in Boston. Aftershocks were felt for much more than a year.

The Pacific Northwest was shaken by an enormous earthquake on January 26, 1700. Scientists estimate the magnitude of the Great Cascadia Subduction Zone Earthquake to have been at least 8.0 and perhaps as high as 9.0. In addition to the strong ground shaking in Canada, Washington and Oregon, the quake generated local tsunamis and a large tsunami that reached Japan. Although the Cascadia area was sparsely populated in 1700, native people recorded stories of the severe shaking, tsunamis and coastal subsidence.

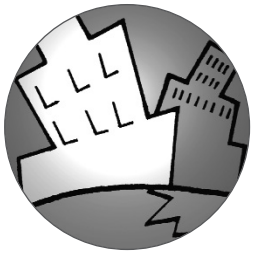
The Great Alaskan (or Good Friday) Earthquake and Tsunamis struck March 17, 1964, the quake with an estimated magnitude of 9.2. This was the largest earthquake in the United States ever recorded by instruments and the second largest to date worldwide. (The largest recorded earthquake occurred in Chile in 1960.) The 1964 quake directly caused 9 deaths, and in addition the tsunami generated by the earthquake caused 115 deaths in Alaska, 4 in Oregon and 13 in California.

Earthquake Science

What Is the Earth Made of?
The earth is composed of layers of rock, which are progressively hotter and denser toward the center. The earth's core is composed of nickel and iron. The inner core is a very hot, very dense solid ball surrounded by an outer core of molten metal. The thickest layer of the earth, called the mantle, surrounds the core. The mantle consists of three layers of rock. Although solid, much of the rock in the mantle is so hot that it flows very slowly. When the earth was formed, the outer surface cooled and hardened into the lithosphere. The coolest and most brittle section of the lithosphere, the outermost layer of the earth, is called the crust. Almost all earthquakes occur in the crust where the rocks are cool enough to be brittle. The crust under the ocean is much thinner and younger than the crust under the continents.

For younger students (K–2), the *Masters of Disaster* curriculum simplifies by comparing the earth to an apple, with the earth's crust analogous to the apple's skin, its mantle to the apple's flesh, and its core to the apple's core. For grades 3–5 and 6–8, the curriculum provides more detail about the composition of the earth.

As the lithosphere cooled and hardened, it cracked into huge slabs, or pieces, called plates. There are seven large plates and more than a dozen smaller ones. These lithospheric, or tectonic, plates move slowly, driven by molten rock flowing slowly in the underlying mantle. Some scientists have described this process as similar to potato chips moving on a bowl of peanut butter. The overall rate of movement is slow—the tectonic plates drift at about the same rate as fingernails grow (an inch or two per year). The process of plate tectonics is the geological theory of these moving plates. The theory provides



Earthquakes

Background

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scientists with a unifying framework to explain the earth's constantly changing features.

What Happens When the Plates Move?
Postulated in the late 1960s and early 1970s, the theory of plate tectonics accounts for most of the world's geologic features. The forces that drive these plates are a matter of ongoing research, but modern scientific opinion considers the theory that convection currents, systems of heat exchange that take place deep within the earth's mantle, are the prime movers. Gravity may be a key factor in the movement, as cool, dense crust sinks at subduction zones, for example, the coastlines of the Pacific Northwest, Japan and Alaska. As plates spread apart, hot magma, which is less dense, moves upward to fill the gap, cooling to form brand-new oceanic crust, such as that forming at the center of the widening Atlantic Ocean, for example. This process is ongoing, resulting in slow movement in the mantle.

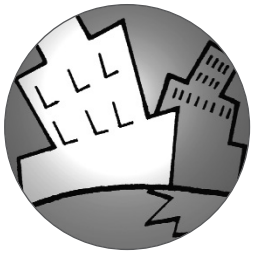
In general, plate movement belongs to one of three types: spreading, colliding or sliding. When plates are spreading, or separating from each other, their movement is called divergent. When they are colliding, or pushing each other, their movement is called convergent. Movement in which plates slide past each other is called lateral or strike-slip movement. Volcanoes tend to form where oceanic and continental plates collide, but they can also form over a fairly stable "hot spot" in the mantle, where a plume of hot magma forces its way through the crust, forming volcanoes. As the crust moves, volcanoes build from the sea floor, become islands, erupt and eventually become extinct, as the plate drifts and another volcano in the chain develops. The islands of Hawaii are a prime example of hot-spot volcanoes.

What Is an Earthquake?
An earthquake is felt as a sudden, rapid shaking on the surface of the earth. This shaking can last a few seconds or a few minutes or more. Very few quakes last longer than a minute. Earthquakes happen because of a sudden slip on a fault, or plane, in the earth's surface where the rocks on one side move up, down or sideways relative to the other side. The constant movement of the earth's plates stresses the upper crust. When the crust can no longer absorb the stress, energy is released in the form of an earthquake.

Large earthquakes are followed by aftershocks, smaller earthquakes that follow the main shock—minutes, hours, weeks, months and even years later. Smaller earthquakes, known as foreshocks, may precede the largest quake in a series. In general, the larger the main shock, the larger and more numerous the aftershocks.

How Do We Measure Earthquakes?
The severity of an earthquake can be expressed in terms of both magnitude and intensity. The two terms are quite different, and they are often confused.

Magnitude is related to the amount of seismic energy released at the hypocenter of the earthquake. It is based on the amplitude of the earthquake waves recorded on instruments that have a common calibration. The magnitude of an earthquake is thus represented by a single, instrumentally determined value. Magnitude is expressed as an Arabic numeral. There are several



Earthquakes

Background

magnitude scales (the Richter scale is an example of an early magnitude scale that is no longer used by seismologists), but all use logarithmic relations to express the degree of ground motion. Each unit increase in magnitude represents an increase in the size of the recorded signal by a factor of 10. Therefore, a magnitude 7 earthquake would have a maximum signal amplitude 10 times greater than that of a magnitude 6 earthquake and 100 times greater than that of a magnitude 5 earthquake. Seismologists refer to the size of an earthquake as moderate (magnitude 4–5), large (magnitude 6), major (magnitude 7) or great (magnitude 8). The magnitude generally must be at least 2.5 or 3.0 before the intensity nearby is strong enough to be felt.

The *hypocenter* is the focus point of an earthquake; epicenter, the word most often heard, is the point on the earth's surface directly above the focus of an earthquake.

Intensity is based on the observed effects of ground shaking on people, buildings and natural features. It varies from place to place within the disturbed region, depending on the location of the observer with respect to the earthquake epicenter. The modified Mercalli Intensity Scale measures these effects. A given earthquake has only one magnitude, but its intensity varies depending on where the shaking is observed.

What is a Tsunami?
A tsunami is a series of large ocean waves. They can travel rapidly over large distances and cause great damage when they reach the shore, often arriving as a series of waves over the course of hours. Tsunamis are usually caused by earthquakes that suddenly raise or drop the seafloor, but they have been generated by landslides (which may have been generated by earthquakes or volcanoes); the impact of asteroids; or melting glaciers as they break apart and shed large icebergs into the sea. Tsunamis can be generated locally or from a distance, with the waves traveling across the ocean at the speed of a jet plane. Locally generated tsunamis may arrive minutes after a strong earthquake has been felt.

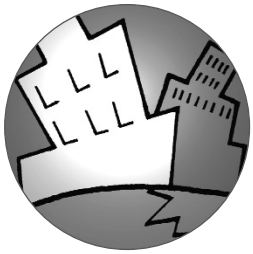
Earthquake Safety

What Is the Risk?
Ground shaking from earthquakes and their aftershocks can cause buildings and other structures to collapse; trigger fires, flash floods, tsunamis, avalanches and landslides; and disrupt essential services such as power, gas and telephone. Structures built on unconsolidated landfill or other unstable soil, and unsecured homes are at risk because they can be shaken from their foundation during a quake. As buildings shake, furnishings and stored items can move, break or fall. Aftershocks can cause further damage to already weakened structures.

Most earthquake-related injuries result from collapsing structures, flying glass, falling objects, landslides and fires—not ground movement. The occurrences of future earthquakes are not predictable, but much of the earthquake-related damage is predictable and preventable. Stricter building codes, retrofitting programs, hazard hunts, and family and community emergency plans increase the chances of mitigating the effects of an earthquake.

American Red Cross

Visit the American Red Cross Web site at *www.redcross.org/disaster/masters*



Earthquakes

Background

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What You Need to Do to Be Ready for Earthquakes

Contact your local chapter of the American Red Cross, the local emergency management office, the state geological survey or the department of natural resources for information about historical earthquakes and earthquake preparedness for your area. Although there are 41 states or territories at moderate to high risk, many people do not realize the potential for earthquakes in their area.

The checklists that follow can help you prepare for an earthquake and minimize your risk during and after an earthquake.

What to Do Before an Earthquake

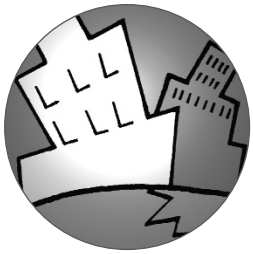
Develop a family disaster plan. (Call your local chapter of the American Red Cross and refer to the lesson plans in *Masters of Disaster*'s *Be Disaster Safe*.)

- ❑ Identify safe places in your home and workplace where you can take cover during an earthquake.
- ❑ Practice the Drop, Cover and Hold On procedure with all family members.
- ❑ Consider the special needs of your family members, the very young, the elderly and anyone with physical limitations as you make your plans.
- ❑ Keep sturdy shoes and flashlights at the bedside.
- ❑ Consider power-failure lights or other emergency lighting.

Assemble a family disaster supplies kit. (Call your local chapter of the American Red Cross and refer to the lesson plans in *Masters of Disaster*'s *Be Disaster Safe.*)

Reduce hazards:

- ❑ Bolt bookcases, china cabinets and other tall furniture to wall studs. Brace or anchor high or top-heavy objects. During an earthquake these items can fall over and cause damage or injury.
- ❑ Secure items that might fall (televisions, books and computers). Falling items can cause damage or injury.
- ❑ Install strong latches or bolts on cabinets. The contents of cabinets can shift during the shaking of an earthquake. Latches will prevent cabinets from flying open and contents from falling out.
- ❑ Move large or heavy objects and fragile items (glass or china) to lower shelves. There will be less damage and less chance of injury if these items are on lower shelves.
- ❑ Store breakable items, such as bottled foods, glass and china, in low, closed cabinets with latches. Latches will help keep the contents of cabinets inside.



Earthquakes

Background

- ❑ Store weed killers, pesticides and flammable products securely in closed cabinets with child-safe latches, on bottom shelves. Chemical products will be less likely to create hazardous situations from lower, confined locations.
- ❑ Hang heavy items, such as pictures and mirrors, away from beds, couches and anywhere else people sit or sleep. Earthquakes can knock things off walls, causing damage or injury.
- ❑ Brace overhead light fixtures. During earthquakes, overhead light fixtures are the most common items to fall.
- ❑ Strap the water heater to wall studs. The water heater will be your best source of drinkable water following an earthquake. Protect it from damage and leaks.
- ❑ Bolt down any gas appliances. After an earthquake, broken gas lines frequently create fire hazards.
- ❑ Check to see if your home is bolted to its foundation. Homes bolted to their foundations are less likely to be severely damaged during earthquakes. Homes that are not bolted have been known to slide off their foundations, and many have been destroyed or made uninhabitable.

What to Do During an Earthquake

- ❑ If you are inside, Drop, Cover and Hold On. When you first feel an earthquake, move to the closest safe place. Drop under a sturdy table or against an inside wall. Protect your face with one arm and hold on if you can. It is very dangerous to try to leave a building during an earthquake because objects can fall on you. Many people are killed when they run out of buildings and are hit by debris falling from collapsing walls. In buildings in the United States, you are safer if you stay inside. Drop, Cover and Hold On during every earthquake.
- ❑ If you are physically unable to Drop, Cover and Hold On, but are able to move a short distance away from windows that might shatter or tall furniture that might fall, do so. If seated, stay where you are and brace yourself in place.
- ❑ In a wheelchair, turn away from windows and set the brake. If a hard hat or helmet is available, put it on.
- ❑ Teachers must Drop, Cover and Hold On, even if some students are not able to protect themselves. The teacher will be needed to assist all students after the ground stops shaking, so it is important that he or she be protected during the earthquake.
- ❑ If you are in bed, hold on and stay there, protecting your head with a pillow. You are less likely to be injured staying where you are. Broken glass on the floor has caused injury to those who have rolled to the floor or tried to walk before putting on shoes.
- ❑ Stay indoors until the shaking stops and you are sure it is safe to exit. Many injuries happen when people try to run during the shaking of an earthquake.
- ❑ Stay away from windows. Windows can shatter with such force that you can be injured several feet away.

American Red Cross

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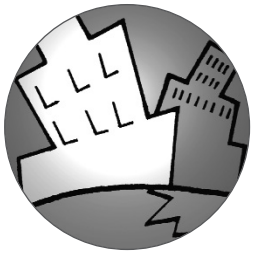

Earthquakes

Background

- ❑ In a high-rise building, expect the building to sway. Move to the center of the building, if possible. Stay away from elevators. Fire alarms and sprinklers may activate during a quake, even when there is no fire.
- ❑ If you are outdoors, find a clear spot away from buildings, trees, streetlights and power lines. Drop to the ground and stay there until the shaking stops. Injuries can occur from falling trees, street lights, power lines and building debris.
- ❑ If you are in a vehicle, pull over in a clear location, stop and stay there with your seat belt fastened until the shaking has stopped. Trees, power lines, poles, street signs and other overhead items may fall during earthquakes. Stopping will help reduce your risk, and a hard-topped vehicle will help protect you from flying or falling objects. Once the shaking has stopped, proceed with caution. Avoid bridges or ramps that might have been damaged by the quake.

What to Do After an Earthquake

- ❑ Assess your situation to determine what to do next. Look around. Fire, the release of hazardous materials, or severe damage to your building indicates that you and everyone else must evacuate the building as quickly as possible.
- ❑ In an area prone to tsunamis, move to higher ground after a big earthquake.
- ❑ Check yourself for injuries. People often tend to others without checking their own injuries. You will be better able to care for others if you are not injured or if you have received first aid for your injuries.
- ❑ Protect yourself. If possible, put on long pants, a long-sleeve shirt, sturdy shoes, work gloves and a hard hat to protect you from danger caused by broken objects.
- ❑ Expect more earthquakes. Each time you feel one, Drop, Cover and Hold On.
- ❑ If possible, help injured or trapped people. Try calling 9-1-1 or your area's emergency number for serious injuries and administer first aid when appropriate.
- ❑ Do not try to move seriously injured people unless they are in immediate danger of further injury.
- ❑ Look for and extinguish small fires. Eliminate fire hazards. Putting out small fires quickly using available resources will prevent them from spreading. Fire is the most common hazard following earthquakes. Fires followed the San Francisco earthquake of 1906 for three days, creating more damage than the earthquake.
- ❑ Leave the gas on unless you smell gas or think it is leaking. It may be weeks or months before professionals can turn gas back on using the correct sequence. Explosions have caused injury and death when homeowners have improperly turned their gas back on without professional assistance.
- ❑ Inspect your home for damage. Get everyone out if your home is unsafe. Aftershocks following earthquakes can cause further damage to unstable buildings. If your home has experienced damage, get out and stay out.

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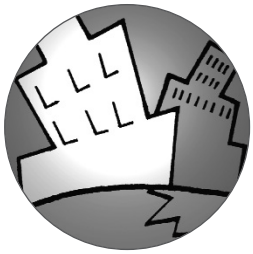

Earthquakes

Background

- ❑ When exiting a building, use the stairs not the elevator.
- ❑ Help neighbors and those who may require special assistance. Elderly people and people with disabilities may require additional assistance. People who care for them or who have large families may need additional assistance in emergency situations.
- ❑ If the electricity is out, use a portable, battery-operated radio or television for updated emergency information and instructions. Local radio and local officials provide the most appropriate advice for your particular situation.
- ❑ Watch out for fallen electrical wires or broken gas lines and stay clear of damaged areas. Hazards caused by earthquakes are often difficult to see, and you could easily be injured.
- ❑ Stay out of damaged buildings. Damaged buildings may be destroyed by aftershocks following the main quake.
- ❑ Use battery-powered lanterns or flashlights if the electricity is out. Kerosene lanterns, torches and candles may tip over or ignite flammables.
- ❑ When entering buildings, use extreme caution. Building damage may have occurred where you least expect it. Carefully watch every step you take.
- ❑ Use the telephone only to report life-threatening emergencies. Telephone lines and cellular connections are frequently overwhelmed in disaster situations. They need to be clear for emergency calls to get through.
- ❑ Be careful of animals. The behavior of pets may change dramatically after an earthquake. Normally quiet and friendly cats and dogs may become aggressive or defensive. Leash dogs and place them in an enclosed place.
- ❑ If you are in a mountainous area or near unstable slopes or cliffs, be alert for falling rocks and other debris that could be loosened by the earthquake. Landslides are common during and after earthquakes.

Tsunami Safety

- ❑ If you live in a tsunami-risk zone, be prepared to go to safe ground inland and uphill after a big earthquake; if the water at the beach recedes or rises suddenly; or if an official tsunami warning has been issued.
- ❑ Move inland and uphill to high ground, following posted evacuation routes if possible.
- ❑ Plan to evacuate to a location 100 feet above sea level or 2 miles inland. If you can't get this high or this far, go as far as you can. The goal is to identify a safe destination that can be reached on foot within 15 minutes.
- ❑ Consider that roads may have been damaged or blocked by the earthquake or may be blocked with traffic.
- ❑ Moreover, the coastline may subside or sink six feet or more, meaning that you may need to move even higher.
- ❑ Be careful to avoid fallen power lines and stay away from buildings and bridges from which heavy objects might fall during an aftershock.
- ❑ After reaching high ground, remain in your safe place. Return home only after local officials tell you it is safe.

American Red Cross

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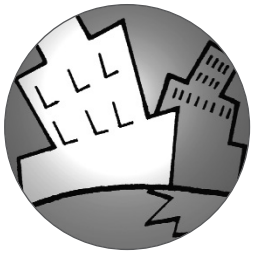

Earthquakes

Background

- ❑ Expect many waves. The first wave in the series is usually not the largest. The tsunami may last for hours.
- ❑ One coastal community may experience damaging waves while a nearby community may not.

Locally generated tsunami

- ❑ Drop, Cover and Hold On during every earthquake. An earthquake that lasts more than 20 seconds in a tsunami-risk area may generate a tsunami. When the shaking stops, gather your family members and evacuate quickly.

Remote or distant-source tsunami

- ❑ Warnings will be issued. Sirens or other public warning systems might be used; the National Oceanic and Atmospheric Administration (NOAA) Weather Radio with programmable features will issue warnings. Radios designed to receive thee broadcasts may also be equipped with Emergency Alert System.
- ❑ The West Coast/Alaska Tsunami Warning Center is responsible for tsunami warnings for California, Oregon, Washington, British Columbia and Alaska.
- ❑ The Pacific Tsunami Warning Center is responsible for providing warnings to Hawaii, United States territories within the Pacific Basin and international authorities.

WATCH and WARNING Definitions

- ❑ A WATCH is issued when conditions favor the occurrence of a tsunami. Listen to NOAA Weather Radio, a Coast Guard emergency frequency station or another reliable source for updated emergency information. Be ready to evacuate. Consider early evacuation, especially if you have special needs, such as small children.
- ❑ A WARNING is issued when authorities have confirmed there is a real threat from a tsunami. If you hear an official tsunami WARNING or detect signs of a tsunami, evacuate at once. Take your disaster supplies kit.

Earthquake and Tsunami Safety at School

- ❑ School and school district plans should be updated annually and tested frequently through drills and exercises. These exercises should include aftershocks and tests of student accounting and student release to parents, guardians and previously designated adults.
- ❑ In tsunami-risk areas, schools should work with their local emergency management offices to establish plans and evacuation routes and areas.
- ❑ Students and staff with disabilities must be included in all planning, drills and exercises. Consider how to communicate with all persons on the campus. If the power is off, elevators and lifts may be inoperable.
- ❑ A system of buddy teachers, paired teachers in adjacent or nearby rooms, enables a pair of teachers to work together in a variety of emergency situations. For example, the students from both classes might be combined in one classroom under the supervision of one teacher, while the other teacher deals with an emergency first aid or other crisis. The two classrooms may evacuate together, with one teacher at the front of the line and the other at the rear.

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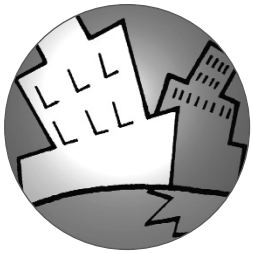

Earthquakes

Background

- ❑ Evacuation after an earthquake should not be automatic. The teacher makes the decision to stay put, evacuate or delay evacuation based on the school policy and his or her evaluation of the situation. The goal should be the safety of all students, and they might be safer inside than outside.

For More Information

To learn more about how to prepare for earthquakes, tsunamis or other disasters, visit the American Red Cross Web site at *www.redcross.org/disaster/masters*.

American Red Cross

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