

DISASTER IN JAPAN

A powerful earthquake recently hit Japan, triggering a towering ocean wave and massive devastation

On March 11, 2011, at 2:46 p.m., the ground in Japan started to shake. Startled residents took cover as a magnitude 9.0 earthquake caused streets to tremble and skyscrapers to sway. Then another blow struck the island nation: A 10 meter (33 foot)-tall wall of water spawned by the quake crashed through towns, leaving behind death and destruction.

The *tsunami*, which means “harbor wave” in Japanese, hit the northeast part of the country (see map, right).

The wave sped several miles inland, sweeping up everything in its path, including ships, cars, and homes. As of press time, thousands had been confirmed dead or are missing. About 450,000 people were left homeless. Hundreds of thousands more were without power following the shut-down of several nuclear power plants that had been severely compromised by the tsunami. Whole towns were evacuated as radiation escaped the crippled power plants.

Part of the reason the tsunami was so devastating was the size of the earthquake behind it. This was tied for the fourth-largest earthquake in recorded history, since about 1900, say experts like Lynda Lastowka, a *seismologist* who studies earthquakes at the United States Geological Survey. It was the largest ever to rock Japan.

Japan’s tremor was nearly 8,000 times as strong as the one that devastated Christchurch, New Zealand, one month earlier. Japan has experienced many earthquakes in the past, so the country was better prepared than most for such a disaster. But even with precautions in place, little could be done to stop the swiftly rising



WALL OF WATER: The tsunami floods the town of Natori—home to more than 70,000 people.



RUNNING FOR COVER: A father and his daughter rescued from the rubble flee the tsunami.

ocean from wiping out entire towns and damaging nuclear reactors.

EARTHQUAKE HOT SPOT

Tsunamis form when an earthquake occurs under the ocean in Earth’s *crust*. This outer layer is made up of huge slabs of rock, called *tectonic plates*, which fit together like puzzle pieces (see *Earth’s Moving Plates*, right). As these plates float on top of a layer of molten rock called the *mantle*, their boundaries—or *faults*—rub against each other. Stress builds until the crust violently bends or slips, releasing the energy as an earthquake.

LEFT: © AP PHOTO IMAGES/THE YOMIURI SHIMBUN; HIROTO SEKIGUCHI; ABOVE: © KYODO VIA AP IMAGES; MAP: JIM MCMARTIN

EARTH’S MOVING PLATES

Earth’s *crust*, or outer layer, is made up of *tectonic plates*. These rocky slabs push against each other along their boundaries, or *faults*. In March, the Pacific plate thrust under the North American plate, generating an earthquake and tsunami off the coast of Japan.





RESCUE EFFORT: Members of Japan's military help a family to safety after the tsunami.

Japan lies in the infamous *Ring of Fire*, in the Pacific Ocean. About 80 percent of the world's largest earthquakes and 90 percent of the world's tsunamis occur in this area. The Ring of Fire is a hotbed of geologic activity because it sits along the edges of the Pacific plate, which is slowly moving against or being forced under neighboring plates.

Japan is situated near a *subduction zone* where the Pacific plate is thrusting beneath the North American plate on which part of the country lies.

Japan's recent earthquake occurred when tension in the fault finally snapped. The North American plate bucked upward and then slammed back down. The ground's movement also caused the water above it to swell then crash back to sea level, generating a tsunami.

DESTRUCTIVE WAVE

Japan's quake occurred about 24 kilometers (15 miles) below Earth's surface. "This was a rather shallow earthquake, and the shal-



STRANDED: The tsunami was strong enough to carry this ferry inland and leave it sitting atop a building.



NUCLEAR CRISIS: The reactors at Fukushima Dai-ichi nuclear power plant were all damaged by the earthquake and ensuing tsunami. In this satellite image, dated March 14, smoke billows from reactor number 3 following an explosion. Reactor 1 had suffered an earlier explosion too.

lower the earthquake, the stronger the shaking," says Lastowka. Initial estimates registered the seismic waves at a whopping 8.9 on the *moment magnitude scale*, which measures an earthquake's strength (see *Earthquake Magnitudes*, right). Later, the quake's magnitude was upgraded to 9.0.

The earthquake's *epicenter*, or point of origin, was just 130 km (80 mi) off Japan's coast. People had very little time to react as vibrations spread out through the earth from where the fault first ruptured and waves followed through the water.

The tsunami's waves started out small as they raced through the ocean at speeds of 805 km (500 mi) per hour—as fast as a jet plane. As they approached the shallow waters near the shore, the waves' peaks scrunched together and grew in *amplitude*, or height. The result was a towering and powerful surge of water that crashed over the miles of concrete seawalls—some as tall as

a four-story building—in place along much of Japan's coast.

SHAKY SAFEGUARDS

Seawalls were only one of Japan's defenses against an undersea quake. Warning systems were set up to alert people, and evacuation routes were in place in coastal areas to lead citizens to higher ground. The megasize earthquake that triggered the tsunami could have done more damage if not for Japan's strict building codes.

Structures in Japan must be built to withstand severe trembling. For example, skyscrapers in the capital city of Tokyo—429 km (267 mi) from the quake's epicenter—are built to sway instead of collapse. Some modern high-rises rest on huge shock absorbers, made of layers of rubber and steel sandwiched together, that dissipate earthquakes' shock waves. "The buildings should behave as much as possible like a fishing rod that bends and springs back, rather than like glass, which breaks as soon

as the earthquake hits," says Bozidar Stojadinovic, a civil engineer at the University of California, Berkeley.

Compare Japan's engineering standards with those of Haiti, which was struck by a 7.0 earthquake last year. Haiti's quake came as a surprise, and the country's poorly constructed concrete buildings toppled from the shaking. New Zealand, on the other hand, has stricter building codes, and the destruction in the Christchurch earthquake was much smaller. Japan's buildings are even better: They withstood the huge earthquake but were no match for the tsunami. "We are improving building codes all the time," says Stojadinovic. "Each new earthquake is like a laboratory where we see what we can do to improve structures and infrastructure." ❁

—Cody Crane & Karina Hamalainen

[WEB EXTRA] For updates on the disaster in Japan, visit www.scholastic.com/scienceworld

EARTHQUAKE MAGNITUDES

Seismologists no longer use the Richter scale. They use the moment magnitude scale to measure the energy an earthquake releases. It's a logarithmic scale that goes from 1 to 10. This means a 2.0 quake releases about 32 times as much energy as a 1.0 magnitude quake. A 3.0 quake releases 1,000 times more energy than one that's 1.0 in magnitude.

MOMENT MAGNITUDE SCALE

- 1-2 MICROEARTHQUAKE:** Almost unnoticeable. Only felt by a few people. Suspended objects may swing a little.
- 3 MINOR EARTHQUAKE:** Felt by people indoors—especially those on upper floors. Vibrations similar to those of a passing truck.
- 4 LIGHT EARTHQUAKE:** Felt by nearly everyone. People are awakened from sleep, and unstable objects move.
- 5 MODERATE EARTHQUAKE:** Felt by everyone. Some heavy furniture moves, and there's some damage to buildings.
- 6 STRONG EARTHQUAKE:** Damage to poorly constructed buildings. Buildings shift off foundations.
- 7 MAJOR EARTHQUAKE:** Few brick and stone buildings remain standing. Damage to well-constructed buildings.
- 8-10 GREAT EARTHQUAKE:** Widespread damage. Few structures remain standing.

LEFT TOP: KYODO VIA AP IMAGES; LEFT BOTTOM: AP PHOTO IMAGES/THE YOMIURI SHIMBUN; RIGHT TOP: DIGITAL GLOBE REUTERS/DIGITAL GLOBE/HANDOUT

SOURCE: UNITED STATES GEOLOGICAL SURVEY