

The Great Wave off Kanagawa is a woodblock print by the Japanese artist Hokusai completed around 1831. Arguably his most famous work, the wave is commonly assumed to be a tsunami wave, but is more likely a large "okinami" wave, a "wave of the open sea" generated by an offshore storm.

## Magnitude 9.0 Earthquake Off the Coast of Honshu Japan

The Great East Japan Earthquake was the most powerful earthquake known to have hit Japan since modern record-keeping began there 140 years ago. The earthquake and resulting tsunami occurred at 2:46 p.m. Japan Standard Time on March 11, 2011. The epicenter of the quake was approximately 45 miles (72 kilometers) east of the Oshika Peninsula at a depth of approximately 15 miles (24 kilometers). The event caused severe structural damage and killed an estimated 20,050 people. The region of Tōhoku (Northern Honshu), and particularly the city of Sendai, received the brunt of the force. Over 4.4 million people throughout Japan were left without electricity and 1.5 million without water.

A state of emergency was declared after cooling systems failed at the Fukushima I Nuclear Power Plant, then later at the Fukushima II plant. After the Japanese Nuclear and Industrial Safety Agency found radiation levels outside the plants to be up to 8 times normal levels, the Japanese government issued a mandatory evacuation of all people within a 12-mile (20-kilometer) radius. Those living within the zone of 12-19 miles (20-30 kilometers) from the power plants were advised to stay indoors. Additionally, the United States government issued a mandatory evacuation of its citizens for all those within a 50-mile (80-kilometer) radius of the plants.

### 1) Earthquake



The brute strength of the earthquake effortlessly split this road in two, right down the middle, as if it were unzipped. According to the United States Geological Survey, the quake ruptured a patch of the earth's crust 150 miles long and 50 miles across. The damage seen here is part of the estimated \$198-\$300 billion it will cost for Japan to rebuild. That makes it the most expensive natural disaster on record, ahead of the previous record, Hurricane Katrina in 2005.

### 2) Tsunami



A boat was trapped in a huge whirlpool, or maelstrom, in a harbor near Oarai City in northeastern Japan. The vortex formed as water drained away from the tsunami and channels on the ocean floor near the coastline created the spinning water. This is essentially the same concept as pulling the plug from a bathtub. Maelstroms are common after large tsunamis and can last several hours as the water recedes. These strong currents posed yet another danger for those at sea when the earthquake struck.

### 3) Nuclear Disaster



People were tested for exposure to radiation after evacuating from the "danger zone" when radiation near the Fukushima Nuclear Power Plants was found to be at a threatening level. The amount of radiation released from the plants was equivalent to one-tenth that of the Chernobyl accident in Russia in 1986. The Japan accident still qualified as a severity level 7 event, the highest on the International Nuclear and Radiological Event Scale.

### Why Japan?

Earthquakes typically occur along faults, which are breaks in the plates of Earth's rocky crust. Japan is particularly susceptible to earthquakes because it lies along the "Pacific Ring of Fire," a narrow zone that outlines the perimeter of the Pacific Ocean. Approximately 90 percent of the world's total earthquakes occur along the Ring of Fire, as do about 80 percent of the largest ones. Japan is located at the intersection of the North American, Eurasian, Philippine, and Pacific plates. Hokkaido and Northern Honshu sit on top of the western tip of the North American plate, while most of Southern Japan sits on top of the Eurasian plate. The Great East Japan Earthquake struck 80 miles (130 kilometers) east of Sendai and 231 miles (373 kilometers) northeast of Tokyo, near the Japan

Trench, a subduction zone where the Pacific plate (under the Pacific Ocean) forces itself under the North American plate (under Japan). Compression forces caused the Pacific plate to thrust under the North American plate, pushing it upward. The earthquake occurred about 15.2 miles under the Pacific Ocean, at a shallow enough depth to push the ocean floor up and away from Japan. Two giant tsunami waves formed and charged across the Pacific, enveloping the northeastern coastline of Honshu and dispersing in all directions.

### Historical Earthquakes in Japan

The Great East Japan Earthquake may have been the biggest quake to ever have hit the country since record-keeping began, but it was far from the first or most devastating quake to rattle the vulnerable islands.

#### Kanto, Japan (September 1, 1923) 7.9

Ninth on the list of most destructive earthquakes, this tremor caused extreme destruction in Tokyo and Yokohama, killing 142,800 people in combination with a tsunami that was generated in Sagami Bay with wave heights as high as 12 meters (39 feet).

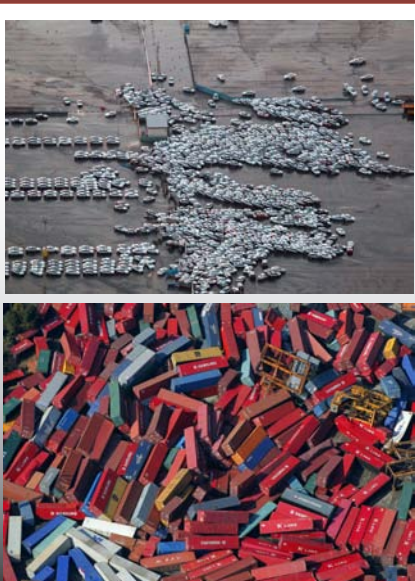
#### Sanriku, Japan (June 15, 1896) 8.5

"Fishermen 20 miles out to sea didn't notice the wave pass under their boats because it only had a height at the time of about 15 inches. They were totally unprepared for the devastation that awaited them when they returned to the port of Sanriku. 28,000 people were killed and 170 miles of coastline were destroyed by the wave that passed under them." -From *The Physics Behind the Wave*

#### Kobe, Japan (January 16, 1995) 6.9



### Costs of the Catastrophe



On top of the thousands of homes, commercial buildings, and essential infrastructure systems that were destroyed, numerous large manufacturers in Japan, such as Toyota, Honda, and Sony, were forced to close manufacturing plants or sharply cut their operations. Factories for many of these industrial companies were damaged by the twin natural disasters and many have been unable to get the supplies they need to resume production. This has significantly impacted an already struggling global economy.

The power of a tsunami: Cars at a manufacturing plant ready for shipment were tossed and deposited like toys (top). Large shipping crates were thrown into a jumbled mess (bottom).

### Nuclear Radiation Impacts

With the ability to alter DNA, man-made nuclear radiation not only threatens humans, but also local food supplies and marine life.



Satellite image of the Fukushima Power Plant after an explosion released dangerous levels of radiation into the air.

Fortunately, due to the ocean's tremendous capacity to dilute radiation, as well as the radiation having a short half life of 8 days, scientists believe it is unlikely that marine life in large areas off Japan's coast will be significantly damaged as long as the Fukushima plants are brought back under control swiftly. Rather, it is more likely that reductions in the reproductive potential of local fish will be observed, further impacting Japan's economy. Plants and animals on land exposed to radiation may also become more susceptible to disease.

### Emergency Preparedness

Although thousands of lives were lost and extensive damage was done due to the the Great East Japan Earthquake, the situation could have been much worse, as the Great Kanto Earthquake demonstrated in 1923. With vulnerability comes preparation, and Japan is arguably the most prepared for strong earthquakes. The country boasts the most sophisticated earthquake early warning system and tsunami detection sensor network in the world, as well as extremely strict building standards. Research is constantly being conducted and improved technologies implemented.

The swift global response also had a significant impact on Japan's ability to begin to confront its short-term needs immediately following the disaster.



The U.S. Navy preparing to deliver supplies to those without food, water, and electricity.

