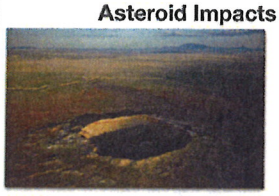
Threats from Space: Asteroid Impacts and Solar Storms

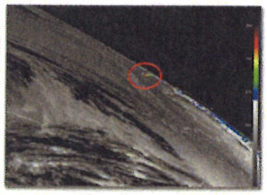



A SAFER EARTH
Professor Barbara Ryden
ryden.1@osu.edu
THE OHIO STATE UNIVERSITY

What would happen if an asteroid or comet were to slam into the Earth?

That depends on the size of the object striking the Earth.

A **small** space rock (a meteoroid) strikes the Earth:
Chelyabinsk, Siberia, 2013 Feb 15



Chelyabinsk meteoroid:

speed = 40,000 mph (Mach 60)
diameter = 20 yards
mass = 10,000 tons
breakup altitude = 18 miles
energy released = 0.5 megatons

Most damage was done by its sonic boom.
1500 people were badly injured (mostly from flying glass).
Cost estimate ~ 1 billion rubles (30 million dollars).

A **medium** space rock (asteroid) or iceball (comet) strikes Earth:
Tunguska, Siberia, 1908 Jun 30

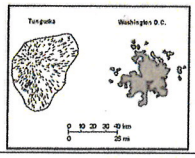

Part of the 800 square miles of flattened forest.


Lake Cheko: a possible impact crater, half a mile across.

Tunguska asteroid:

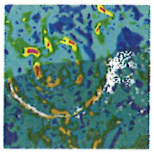
speed = 40,000 mph
diameter = 100 yards
mass = 1 million tons
breakup altitude = 4 miles
energy released = 12 megatons

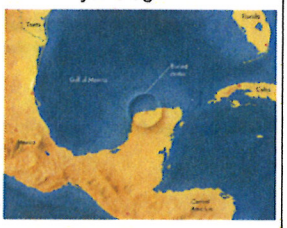
80 million trees were flattened.
A thousand reindeer were killed.
People were knocked down 300 miles away.

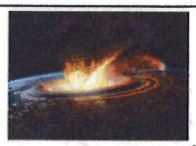


A **REALLY BIG** asteroid or comet strikes the Earth:
Chicxulub, Mexico, 65 million years ago.

Chicxulub crater:
64.98 million years old
110 miles across



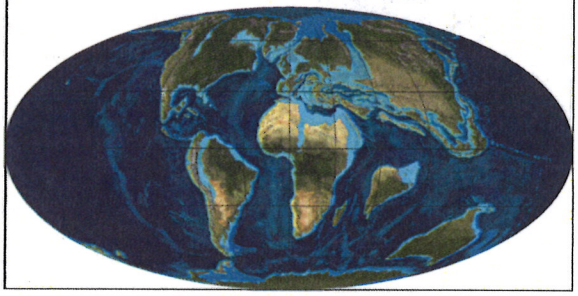




Chicxulub asteroid:

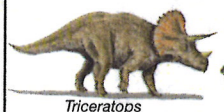
speed = 40,000 mph
diameter = 6 **miles**
mass = 1 **trillion** tons
energy released = **100 million** megatons

World map: 65 million years ago



An asteroid struck the Earth 65 million years ago.

Mass extinction of dinosaurs (and many other organisms) took place 65 million years ago.


Triceratops

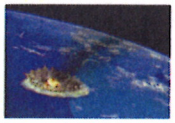

Dimetrodon


Ammonite

COINCIDENCE?

Indirectly, a large impact can cause mass extinctions.

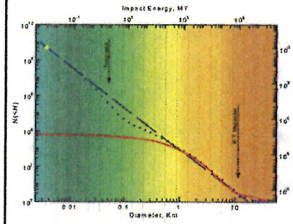
Collision ejects dust into atmosphere.
Months of darkness & cold.
Death of plants.
Death of herbivores.
Death of carnivores.


Tsunami


Firestorms


Acid rain

How often do impacts occur, **on average?**



Small impacts (Chelyabinsk) once per decade.

Medium impacts (Tunguska) once per century.

Really big impacts (Chicxulub) once per 100 million years.

What to do?

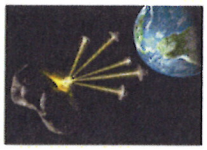
Small: Step away from the window.

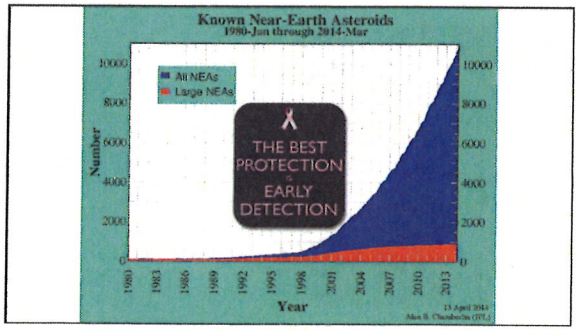
Medium: Monitor the sky with wide-angle telescopes.
We can detect a Tunguska-sized object a day in advance.
Evacuate.

Really big: Monitor the sky with wide-angle telescopes.
We can detect a Chicxulub-sized object months in advance.
What then?

Do **not** send Bruce Willis to blow it up.

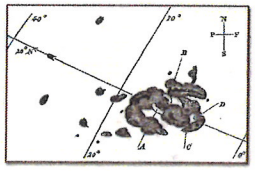
Send an unmanned rocket to *gently* nudge it, and change its orbit.



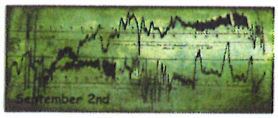


Worst recorded **solar storm**:
The Carrington Event, September 1859

Richard Carrington, a British astronomer,
saw two patches of intensely bright light in a sunspot.

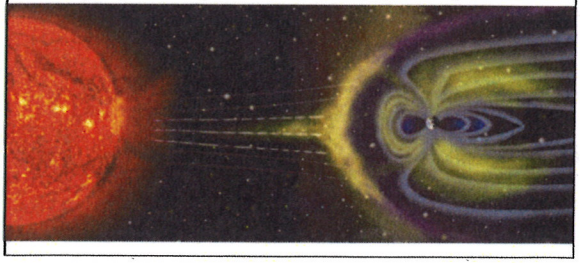


Carrington's bright solar flares were followed 18 hours later by disturbances to Earth's magnetic field and flamboyant auroras.

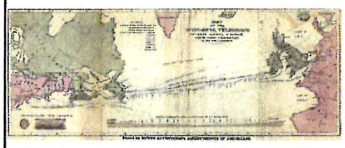


Magnetic field measured at
Kew Gardens, near London.

Conclusion: Earth's magnetic field was pummeled by fast-moving charged particles (protons & electrons) ejected by the Sun.



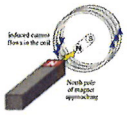
Earth's changing magnetic field severely damaged the telegraph network in September 1859.

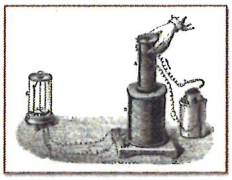


First transatlantic telegraph cable (1858)

Telegraph room in the Houses of Parliament (1859)

What caused the damage? A changing magnetic field creates an induction current in a closed loop of wire.

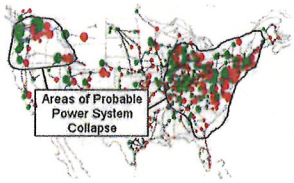




Induction currents in the telegraph wires were greater than they were designed to carry. $P = I^2R$

21st century society is far more "wired" than the Victorians were.

High voltage power transmission lines are vulnerable to induction currents.



Fast protons & electrons also damage the electronics of satellites & high-flying airplanes.

What to do?

Monitor the Sun: 18 hour window between arrival of light and arrival of fast protons & neutrons.

Prepare the power grid: Disconnect transformers, isolate subsections of the power grid.

Kiss orbiting satellites goodbye: Shielding satellites requires a huge mass of heavy metal. It's easier to launch replacement satellites.

Additional resources:

Asteroid impacts:

NASA Near-Earth Object Program (neo.jpl.nasa.gov)

Solar storms:

National Research Council. *Severe Space Weather Events – Understanding Societal and Economic Impacts,* National Academies Press (2008)