Announcements

- Just keep checking Avenue

Question 1

What is the most common trigger for avalanches in recreational accidents?

1. a person's weight added to a slope that is near failure
2. skiers deliberately attempting to release unstable snow before they ski down a slope
3. inflow of warm air funneled upward from a valley, weakening the near-surface layer
4. daytime heating of the upper snowpack, which weakens the near-surface layer
5. bad weather

Question 2

The Calgary flood of 2013 was primarily the result of

1. an outburst from a glacial melt.
2. Ice jams
3. Heavy rainfall in Rockies
4. An earthquake
5. A rain-on-snow event?

Learning Objectives

- Recognize that natural disasters and catastrophes are high-energy events caused by natural Earth processes

- Understand that natural hazards have social, economic and political dimensions that are just as important as the hazards themselves

- Understand the differences among hazard, risk, acceptable risk, disaster, and catastrophe

Learning Objectives, cont.

- Understand the concept that the magnitude of a hazardous event is inversely related to its frequency
- Recognize that many natural hazards are linked to one another
- Recognize that population growth, concentration of infrastructure and wealth in hazardous areas, and land-use decisions are increasing our vulnerability to natural disasters
- Understand that hazardous natural processes can also provide benefits

Natural Processes and Energy Sources

- **Processes**
  - Physical, chemical, and biological ways in which events affect Earth's surface

- **Internal processes come from forces within Earth**
  - Plate tectonics
  - Result of internal energy of Earth

- **External processes come from forces on Earth's surface**
  - Atmospheric effects
  - Energy from the Sun

Definitions

- **Hazard**
  - Probability that a specific damaging event will happen within a particular period of time
- **Risk**
  - A function of the hazard, exposure, vulnerability, and coping capacity
- **Disaster**
  - Hazardous event that occurs over a limited time in a defined area
- **Catastrophe**
  - Massive disaster that requires significant amount of money or time to recover

Disaster Trends

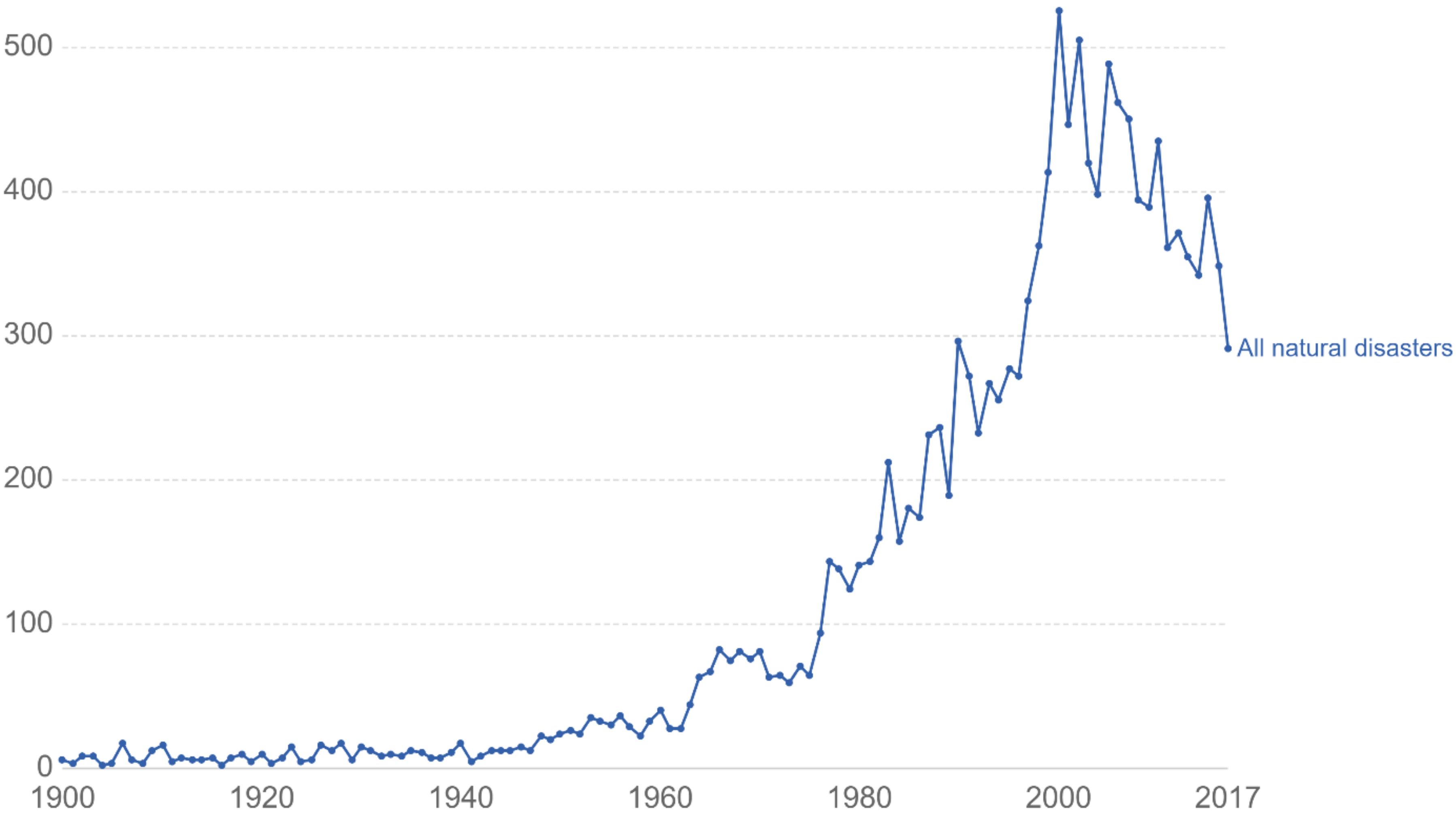
- Recently, there has been an apparent increase in natural disasters
  - Japan tsunami, Nepal earthquake, Haiti earthquake, Hurricane Katrina, 2015 heat wave in southern India, 2018 flooding in Houston

- The United Nations designated the 1990s as the International Decade for Natural Hazards Reduction
  - Mitigation
    - Reduce the effects of something
    - Natural disaster preparation

Number of recorded natural disaster events, All natural disasters

Our World in Data

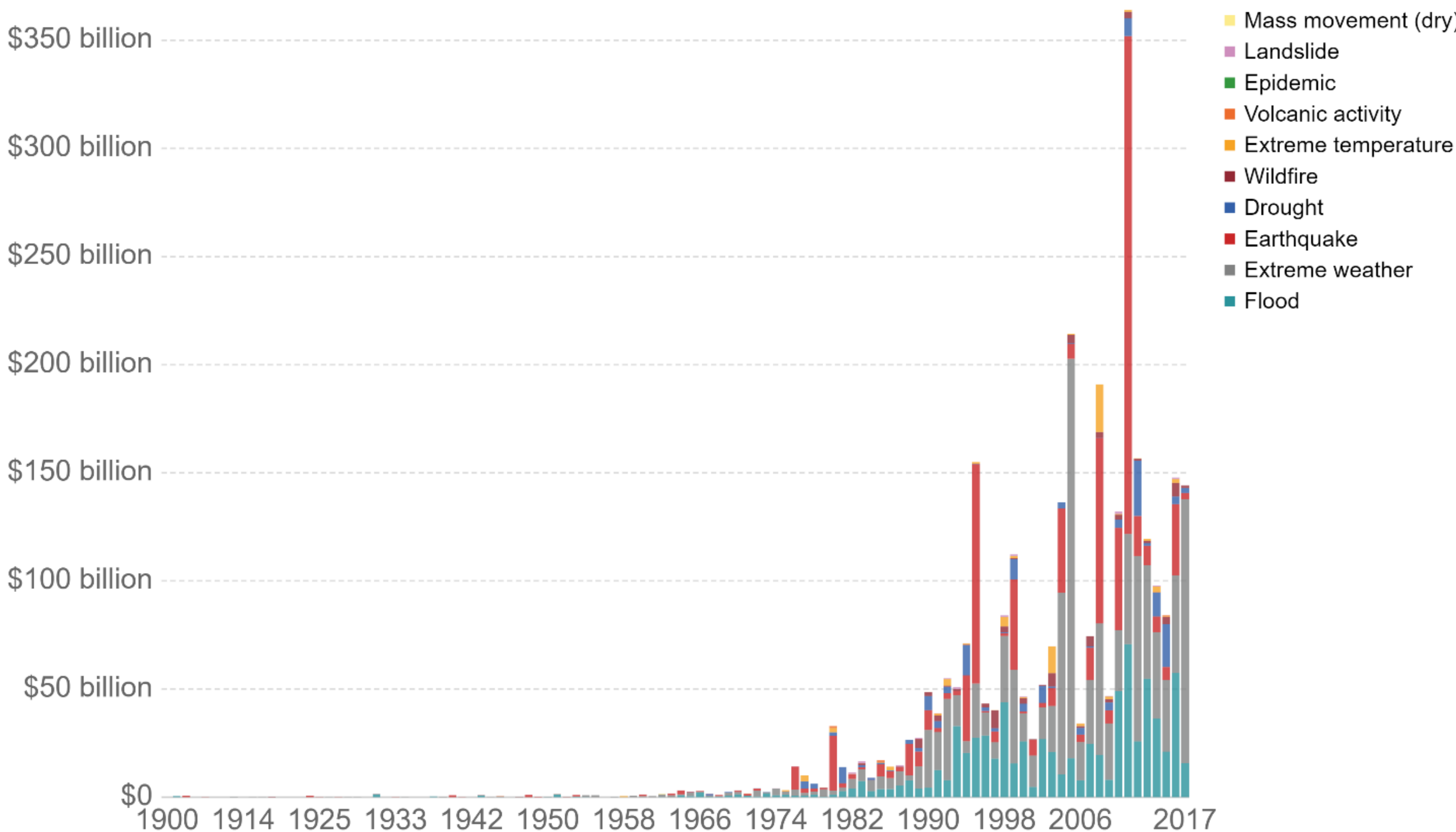
The number of global reported natural disaster events in any given year. This includes those from drought, floods, biological epidemics, extreme weather, extreme temperature, landslides, dry mass movements, extraterrestrial impacts, wildfires, volcanic activity and earthquakes.



Source: EMDAT (2017): OFDA/CRED International Disaster Database, Université catholique de Louvain – Brussels – Belgium

Economic damage by natural disaster type

Global economic damage from natural disasters, differentiated by disaster category and measured in US$ per year.



Source: EMDAT (2017): OFDA/CRED International Disaster Database, Université catholique de Louvain – Brussels – Belgium

Death and Damage Caused by Natural Hazards

- Those hazards that have a great impact on human life may not cause the most property damage

- Hazards vary greatly in their ability to cause catastrophe

TABLE 1.1 Effects of Selected Hazards in Canada and the United States

Hazard	Deaths per Year	Catastrophe Potential
Flood	100	High
Earthquake[a]	>50	High
Landslide	30	Low
Snow avalanche	20	Low
Volcanic eruption[a]	<1	High
Coastal erosion	0	Low
Soil expansion	0	Very low
Hurricane	60	High
Tornado and windstorm	220	High
Lightning	125	Very low
Drought	0	Medium
Heat wave	100s	High
Wildfire[b]	<10	High
Freezing and frozen rain	<10	Medium
Permafrost thaw	0	High
Extraterrestrial impact	0	Very high

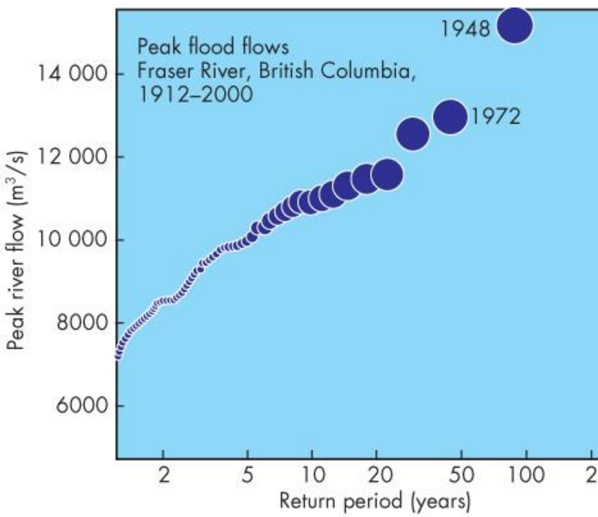
[a] Estimates based on recent or predicted loss over a 150-year period. Actual losses differ considerably from year to year and could be much greater in a given year.

[b] Most deaths are firefighters.

Source: Adapted from White, G. F., and J. E. Haas. 1975. Assessment of Research on Natural Hazards. *Cambridge, MA: MIT Press. Reprinted with permission.*

Magnitude and Frequency of Hazardous Events

- **Impact**
  - Function of magnitude and frequency
  - Also influenced by other factors (e.g. climate, geology, vegetation, land-use, population)



- **Magnitude-Frequency Concept**
  - Inverse relationship between magnitude and frequency
  - $M = Fe^{-x}$

- **The history of an area gives clues to its potential hazards**
  - Maps, historical accounts, weather and climate data
  - Rock types, faults, folds, soil composition

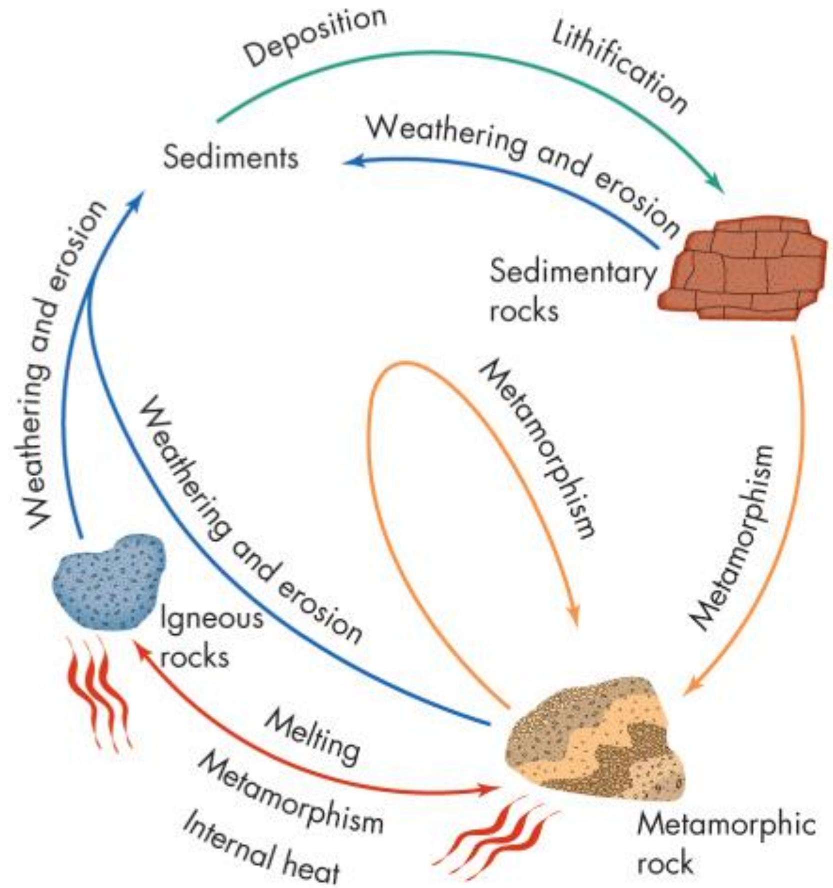
Geologic Cycle

- Geologic conditions govern the type, location, and intensity of natural processes

- **Sub-cycles:**
  - Tectonic cycle (next week)
  - Rock cycle
  - Hydrologic cycle
  - Biogeochemical cycles

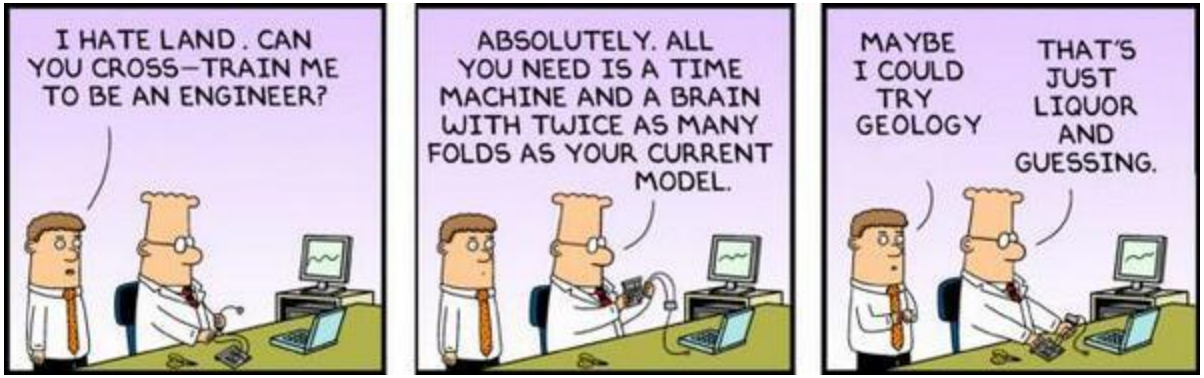
Rock Cycle

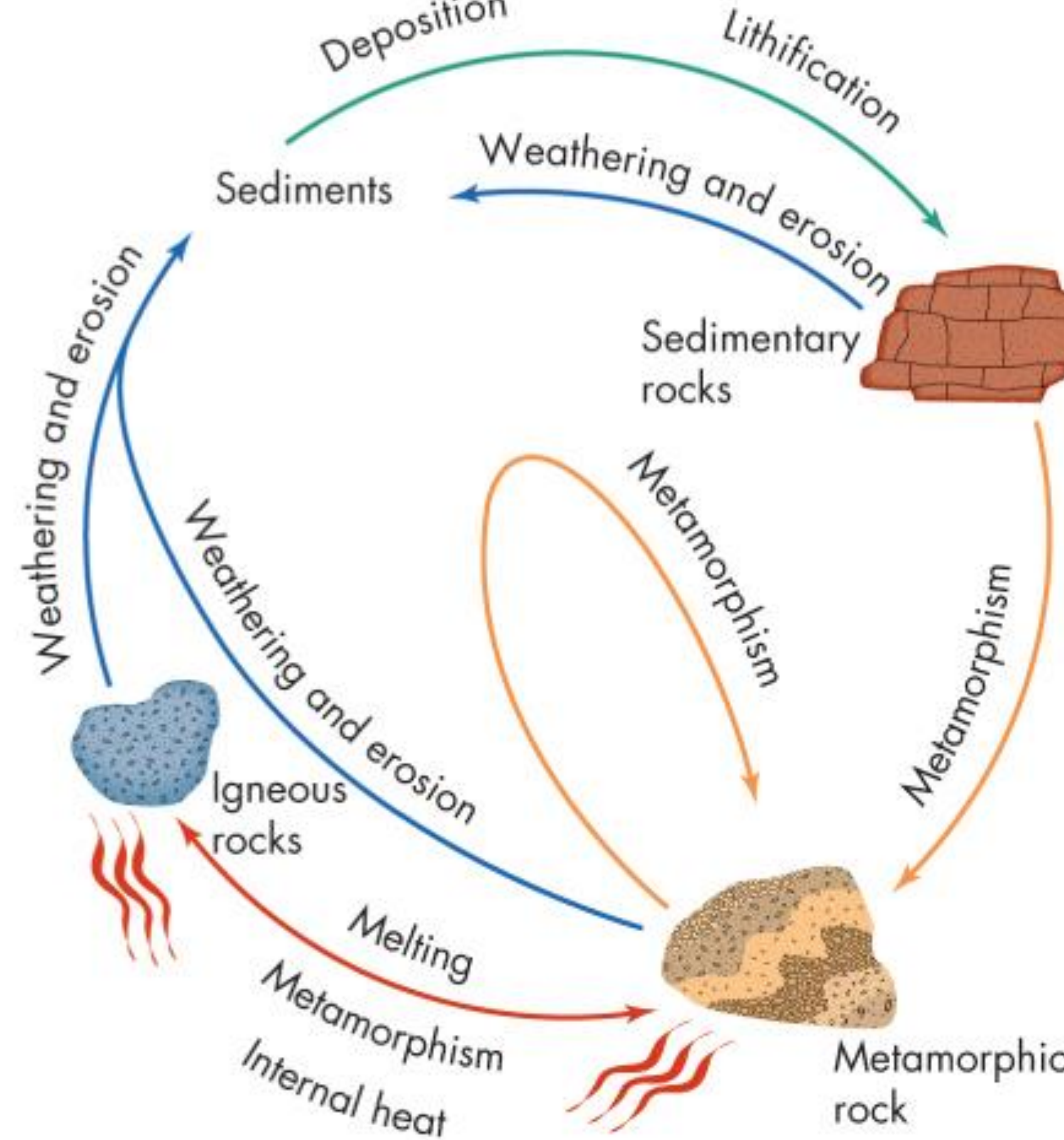
- Rocks are aggregates of one or more minerals
- The rock cycle refers to recycling of three major rock types
- Different rocks are formed by different processes
- Rock types in a location give clues to the geological past and present



Rock Cycle, cont.

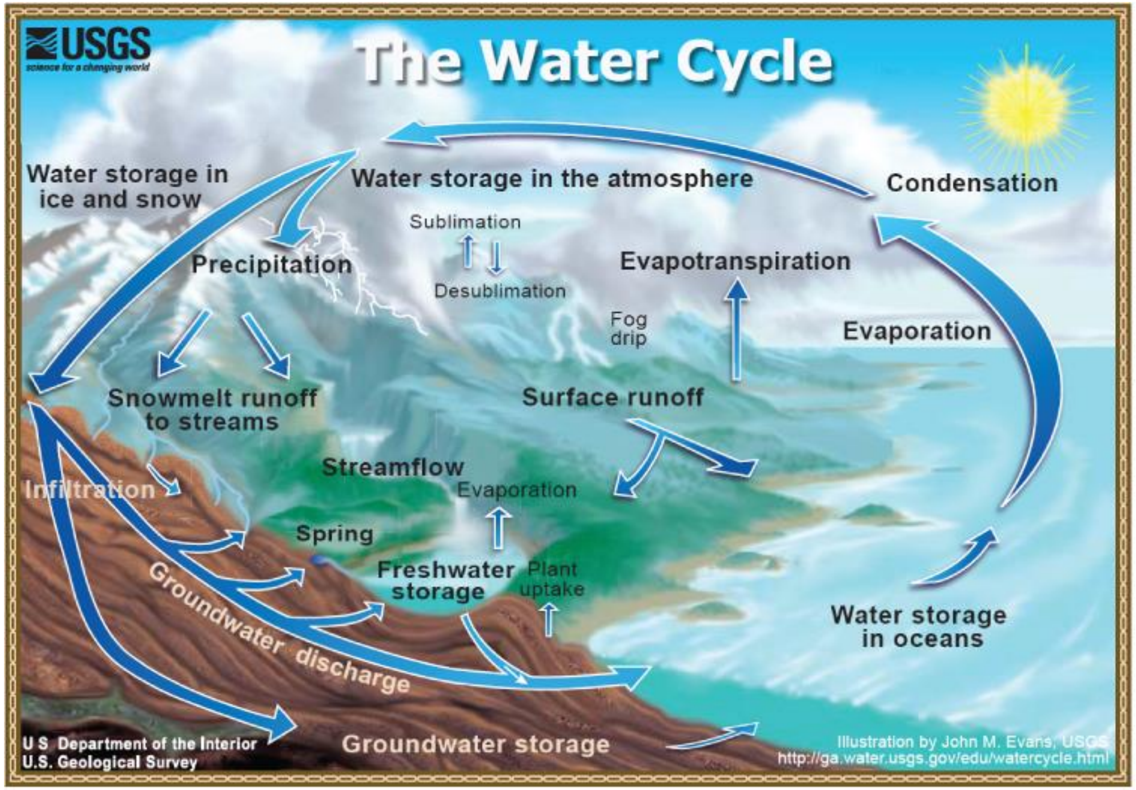
- **Igneous rocks**
  - Form from crystallization of magma
- **Sedimentary rocks**
  - Rocks are weathered into sediment by wind and water
  - Deposited sediment is converted into sedimentary rock by lithification
- **Metamorphic rocks**
  - Rocks are changed through extreme heat, pressure or chemically active fluids




Deposition
Lithification
Sediments
Weathering and erosion
Sedimentary
rocks
Weathering and erosion
Weathering and erosion
Metamorphism
Metamorphism
Igneous
rocks
Melting
Metamorphism
Internal heat
Metamorphic
rock

Hydrologic Cycle

- Solar energy drives movement of water between atmosphere and oceans and continents
- Processes include: evaporation, precipitation, surface runoff, and subsurface flow
- Water is stored in compartments such as oceans, the atmosphere, rivers, streams, etc.
  - Residence time is the estimated average time that a drop of water spends in any compartment
  - Only a small amount of water is active at any given time



◀ **FIGURE 1.9 HYDROLOGIC CYCLE** Idealized diagram showing important processes and transfers that define the hydrologic cycle. *(Illustration by John M. Evans, USGS, http://ga.water.usgs.gov/edu/watercycle.html)*

TABLE 1.2 The World's Water Supply

Location	Surface Area (km^2)	Water Volume (km^3)	Percentage of Total Water	Estimated Average Residence Time
Oceans	361 000 000	1 230 000 000	97.2	Thousands of years
Atmosphere	510 000 000	12 700	0.001	9 days
Rivers and streams	—	1200	0.0001	2 weeks
Groundwater; shallow to depth of 0.8 km	130 000 000	4 000 000	0.31	Hundreds to many thousands of years
Lakes (freshwater)	855 000	123 000	0.009	Tens of years
Ice caps and glaciers	28 200 000	28 600 000	2.15	Hundreds of years to hundreds of thousands of years

Source: Data from U.S. Geological Survey.

Biogeochemical Cycles

- The transfer or cycling of an element or elements through the atmosphere
  - carbon, nitrogen, phosphorus
- Elements and chemical compounds are transferred via a series of reservoirs
- The amounts of elements in each reservoir, and their rates of transfer between each, are known only approximately

Fundamental Concepts for Understanding Natural Processes as Hazards

- 1. Hazards can be understood through scientific investigation and analysis

- 2. An understanding of hazardous processes is vital to evaluating risk

- 3. Hazards are linked to each other and the environment

Fundamental Concepts for Understanding Natural Processes as Hazards

- 4. Population growth and socio-economic changes increase the risk from natural hazards

- 5. Damage and loss of life from natural disasters can be reduced

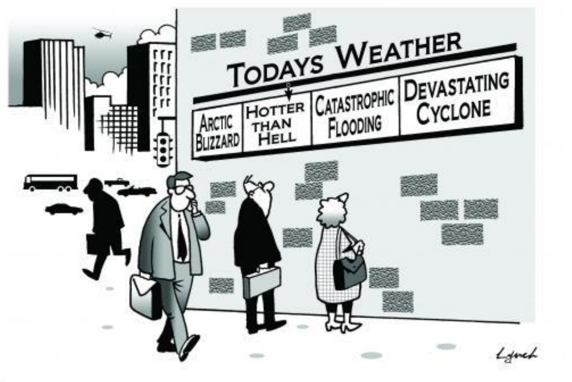
1. Science and Natural Hazards

- Scientists observe hazardous events and form a possible explanation
  - From this explanation, a hypothesis is formed.
  - Data is collected to test a hypothesis.
- Allows for identification of where hazards occur, their magnitude, and their frequency
- Knowledge of past events can be used to determine future risks

Hazardous Processes are Natural

- They are a result of natural forces
- Although we can, to a degree, control some hazards, many are completely beyond our control
- The best solution is preparation

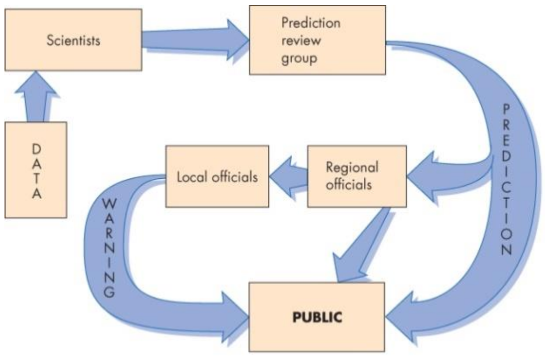
Prediction and Forecast



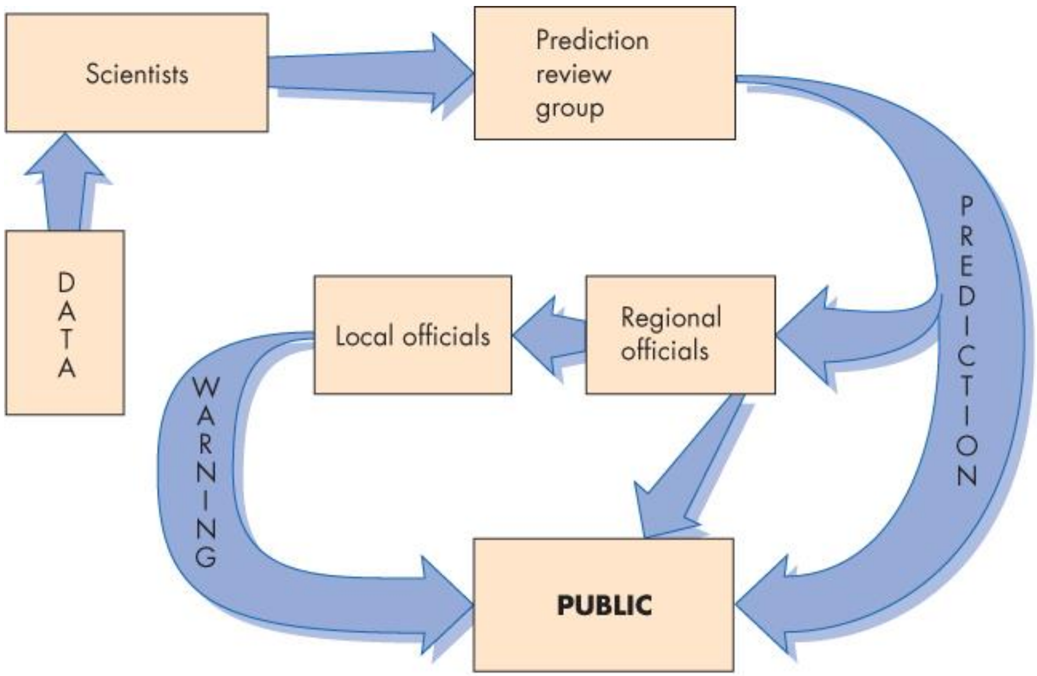
- **Prediction**
  - Specific date, time, and magnitude of the event
- **Forecast**
  - Less precise and has a range of probability for the event
- Some hazards can be predicted, most can be forecasted.

Hazard Reduction

- Identify the location of a probable event
- Determine the probability of event
- Identify any precursor events
- Forecast or predict the event
- Issue a warning the public



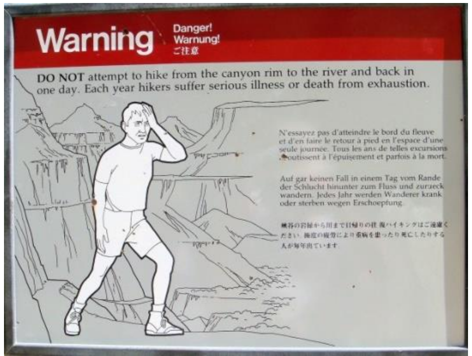
◄ FIGURE 1.10 HAZARD PREDICTION OR WARNING Possible path for issuing a prediction or warning of a natural disaster.



◄ **FIGURE 1.10 HAZARD PREDICTION OR WARNING** Possible path for issuing a prediction or warning of a natural disaster.

2. Understanding Hazardous Processes and Evaluating Risk

- **Risk = (probability of event) x (consequences)**
  - We will be coming back to this concept
- **Consequences:** deaths and injuries to people, damage to property, economic effects, etc.
- **Acceptable risk** is the amount of risk that an individual or society is willing to take



3. Hazards Are Linked

- **Hazards are linked to each other**
  - Some events may cause others
    - Ex: Earthquakes and landslides
- **The physical environment is linked to hazards**
  - Ex: Some rock types are prone to subsidence and landslides

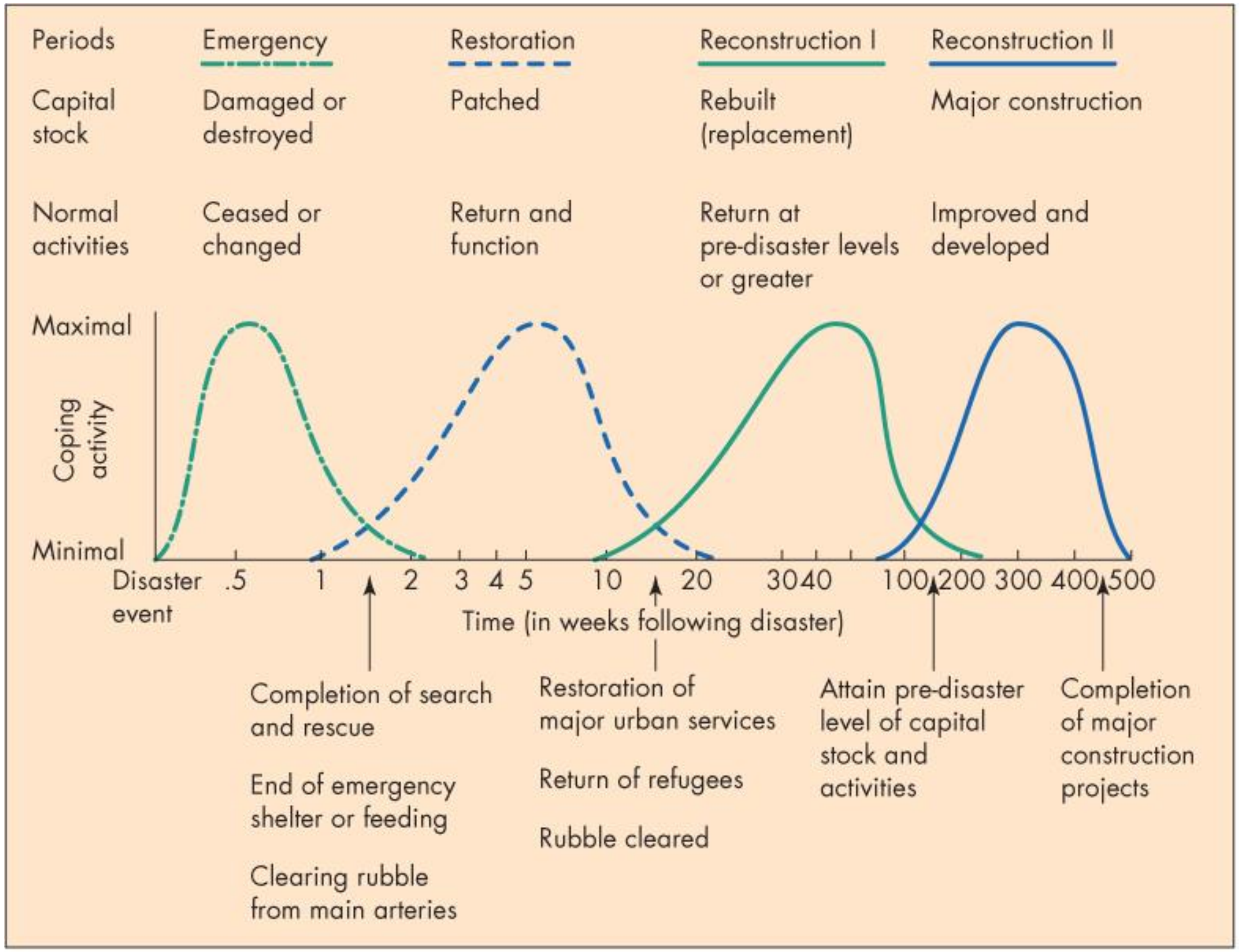
4. Increasing Risk from Natural Hazards

- Concentration of population creates greater loss of life in disaster
- Exponential human population growth puts greater demand on Earth's resources
- Population growth in developing countries is far outstripping that in wealthy jurisdictions

5. Consequences Can Be Reduced

- **Effects from a disaster can be: (really important!)**
  - Direct – people killed, buildings damaged, etc.
  - Indirect – crop failures, starvation, emotional distress, etc.

- **Recovery from disaster**
  - Emergency work
  - Restoration of services and communication lines
  - Reconstruction



◀ **FIGURE 1.13 RECOVERY FROM DISASTER** Generalized model of recovery following a disaster. The first two weeks after a disaster are the period of emergency, during which normal activities cease or are changed. In the restoration phase, which typically lasts several months, normal activities return, although perhaps not at pre-disaster levels. Finally, during reconstruction, the capital stock is replaced, major new construction is completed, and normal activities return. *(From Kates, R. W., and D. Pijawka. 1977. "From rubble to monument: The pace of reconstruction." In* Disaster and Reconstruction*, eds. J. E. Haas, R. W. Kates, and M. J. Bowden, pp. 1–23. Cambridge, MA: MIT Press)*

5. Consequences can be Reduced

- **Move from a reactive response: recovery from disasters and restoration**
- **To a proactive response: avoiding and adjusting to hazards**
  - Land-use planning
  - Building codes
  - Insurance
  - Evacuation
  - Disaster preparedness
  - Artificial control

Natural Service Functions

- **These are benefits that hazards provide**
- **Examples:**
  - Floods provide nutrients for soil
  - Landslides form dams to create lakes
  - Volcanoes create new land

TO DO

- read Chapter 1
- Read over this webpage: https://ourworldindata.org/natural-disasters