

# **Streams and Floods**

## **Chapter 16**

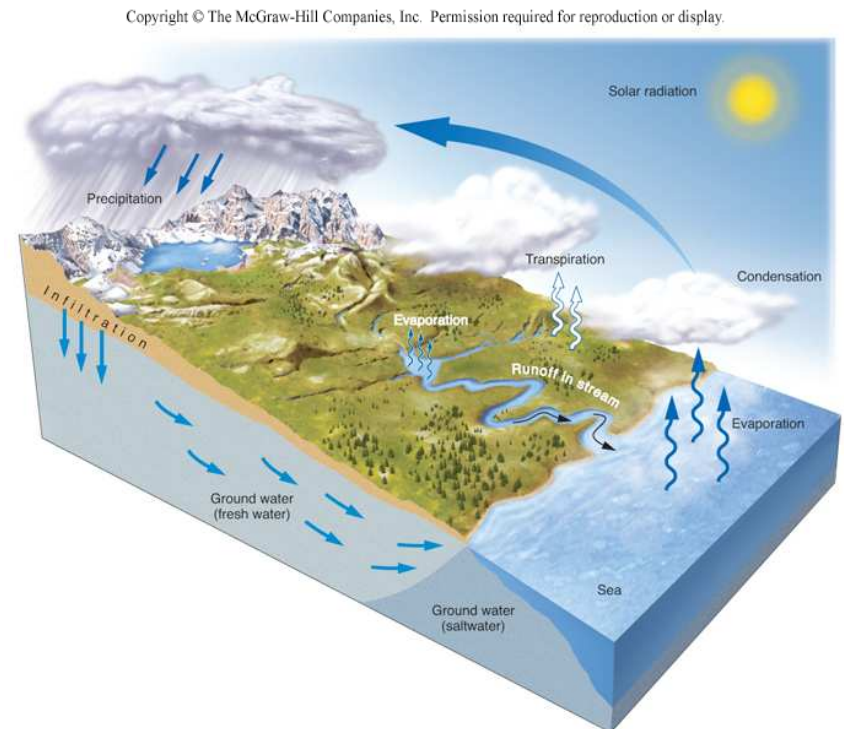
# Running Water

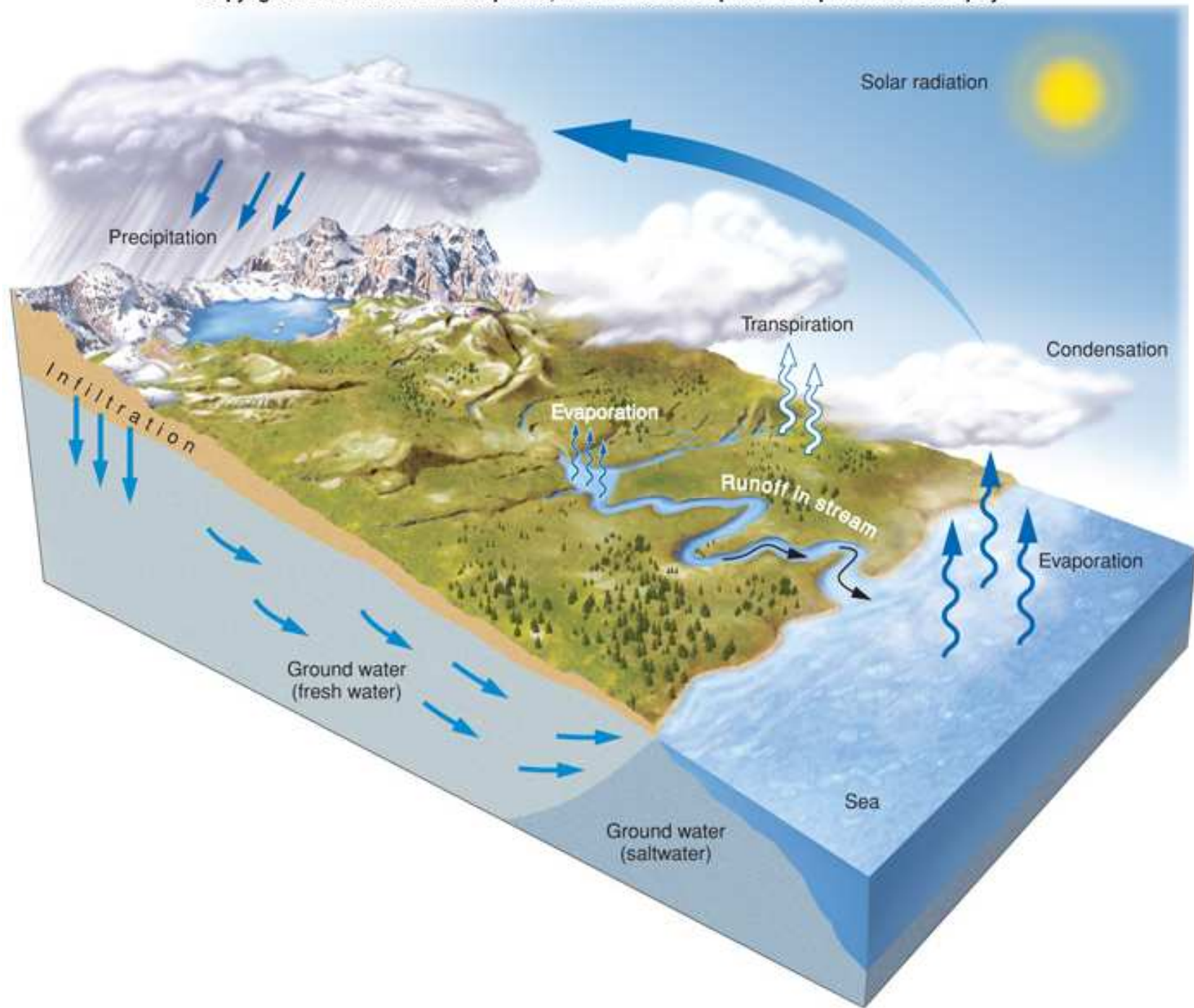
- *Running water* is the most important geologic agent in eroding, transporting and depositing sediment
- Nearly every landscape on Earth shows the results of stream erosion or deposition



# Hydrologic Cycle

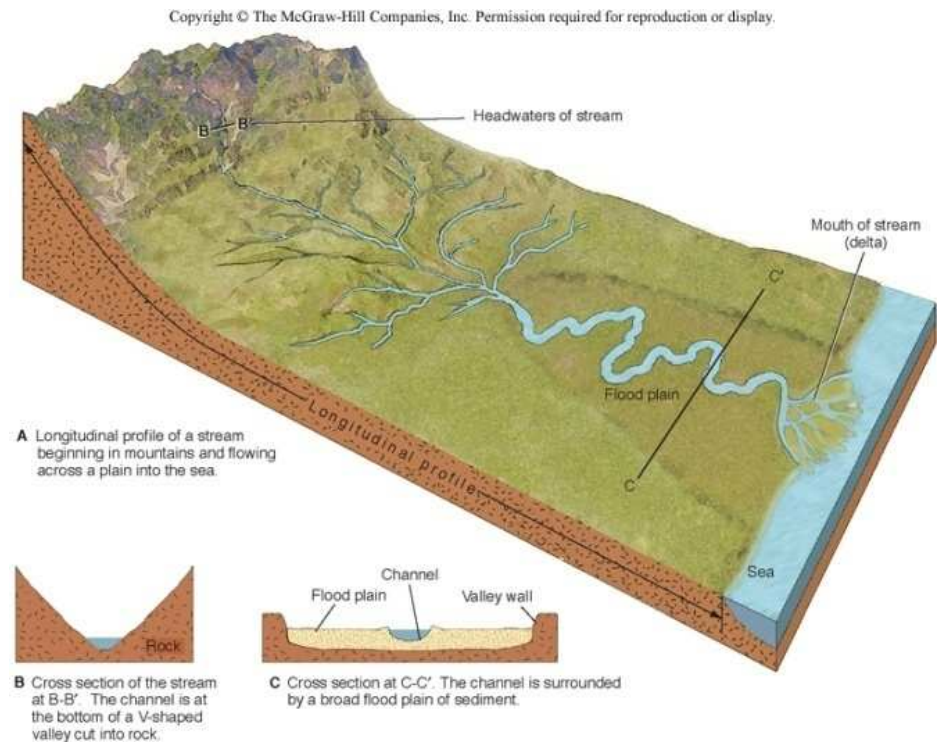
- *Hydrologic cycle* - the movement and interchange of water between the sea, air, and land
  - *Evaporation*
    - Solar radiation provides energy
  - *Precipitation*
    - Rain or snow
  - *Transpiration*
    - Evaporation from plants
  - *Runoff*
    - Water flowing over land surface
  - *Infiltration*
    - Water soaking into the ground





# Running Water

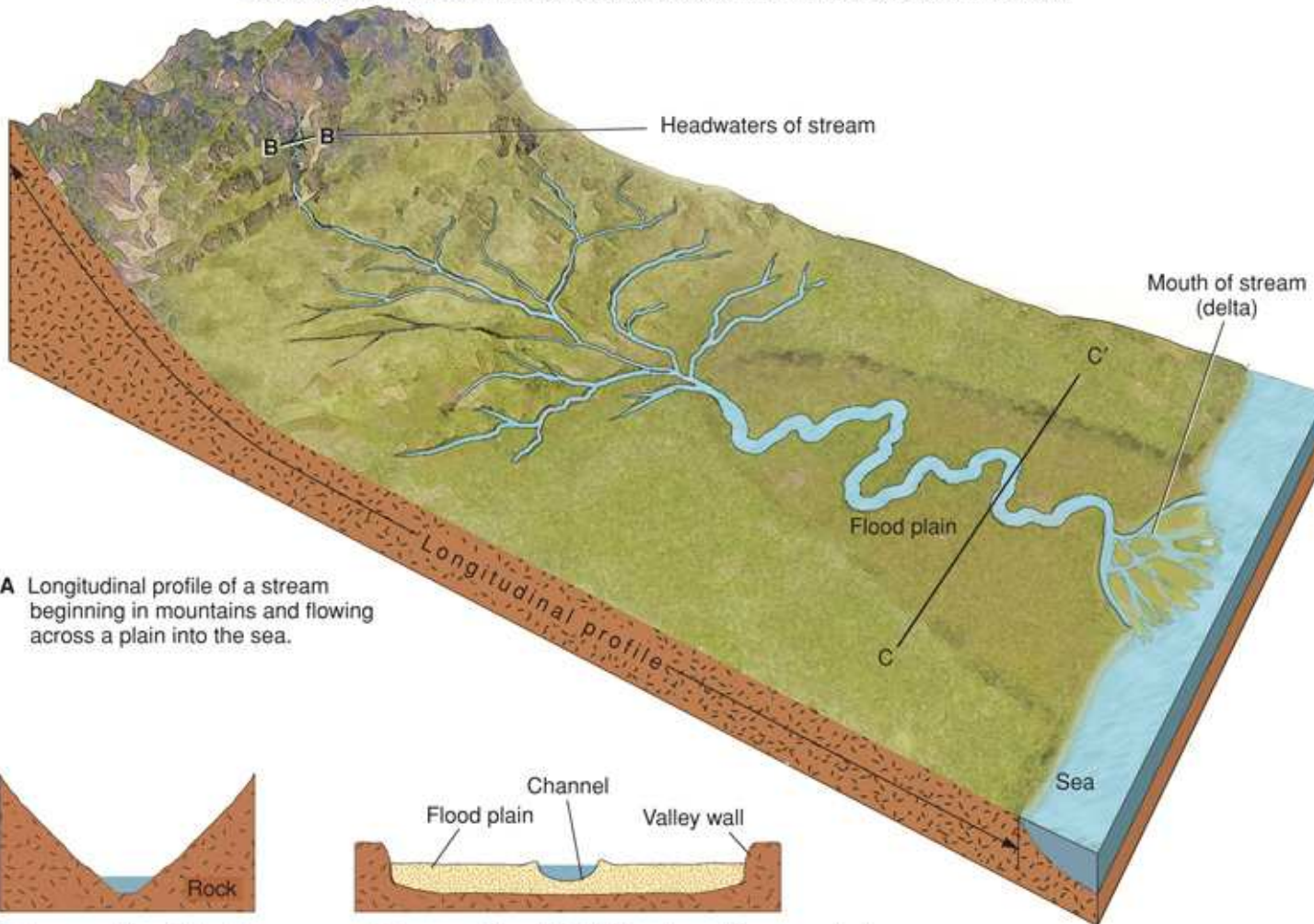
- *Stream* - a body of running water, confined to a channel, that runs downhill under the influence of gravity
  - *Headwaters* - upper part of stream near its source in the mountains
  - *Mouth* - place where a stream enters sea, lake or larger stream



# Stream:

- Channel
- Banks
- Bed
- Gradient
- Floodplain

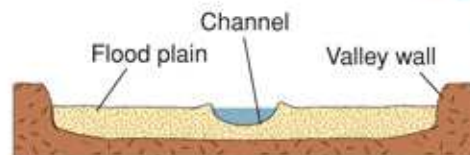
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**A** Longitudinal profile of a stream beginning in mountains and flowing across a plain into the sea.



**B** Cross section of the stream at B-B'. The channel is at the bottom of a V-shaped valley cut into rock.



**C** Cross section at C-C'. The channel is surrounded by a broad flood plain of sediment.

# Running Water

- *Channel* - a long, narrow depression eroded by a stream into rock or sediment
  - Stream *banks* - sides of channel
  - *Streambed* - bottom of the channel
- *Floodplain* - flat valley floor composed of sediment deposited by the stream



# Drainage Basins

- *Drainage basin* - the total area drained by a stream and its tributaries
  - *Tributary* - a small stream flowing into a larger one
- *Divide* - ridge or high ground that divides one drainage basin from another
  - *Continental Divide* separates the streams that flow into the Pacific from those that flow into the Atlantic and Gulf of Mexico



# Drainage Basins

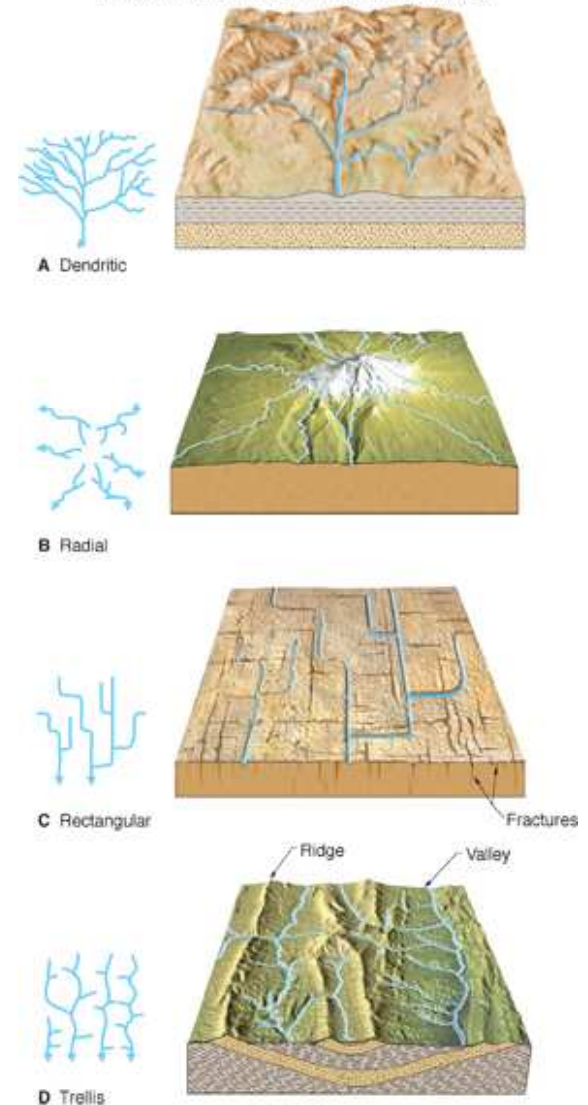


- **Tributaries:** drain into larger streams
- **Distributaries:** drain away from larger streams

# Drainage Patterns

- *Drainage pattern* - the arrangement, in map view, of a stream and its tributaries
  - *Dendritic* - drainage pattern resembling the branches of a tree
  - *Radial pattern* - streams diverge outward like the spokes of a wheel
    - Typically form on conical mountains (volcanoes)
  - *Rectangular pattern* - tributaries have frequent 90° bends and join other streams at right angles
  - *Trellis pattern* - parallel streams with small tributaries meeting at right angles

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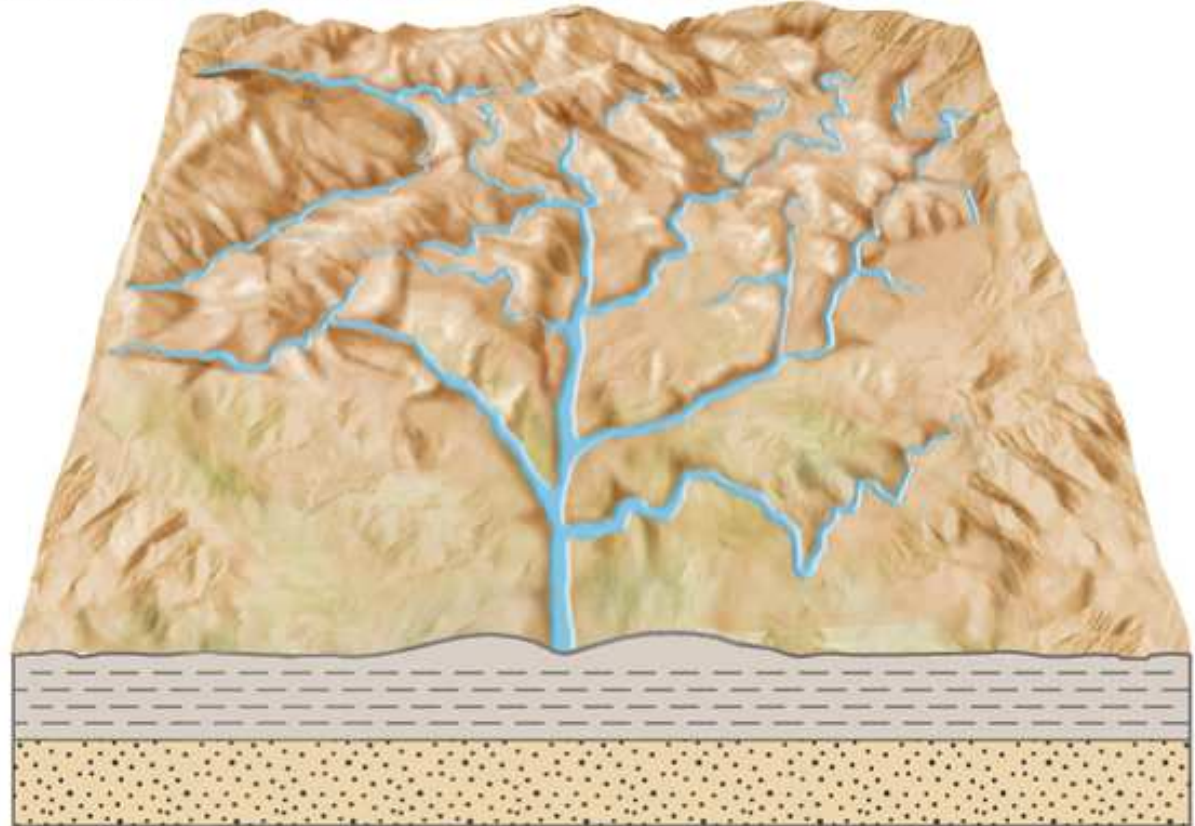


# Dendritic

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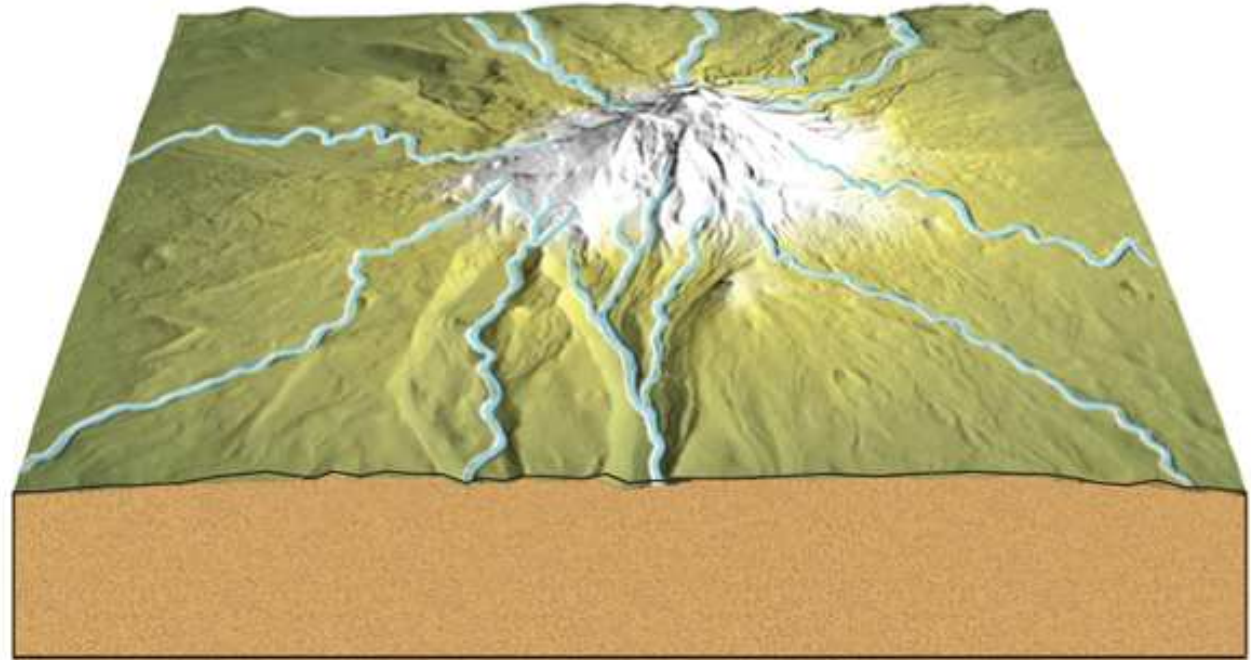
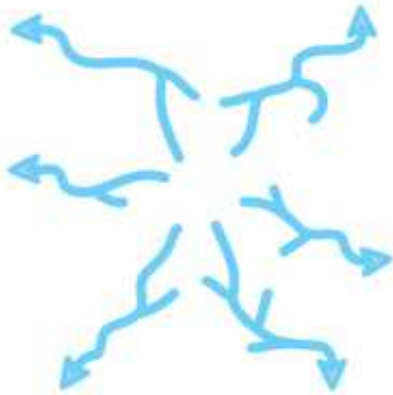


**A** Dendritic



# Radial

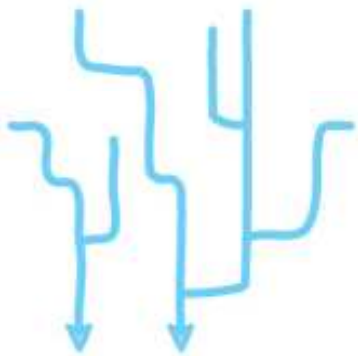
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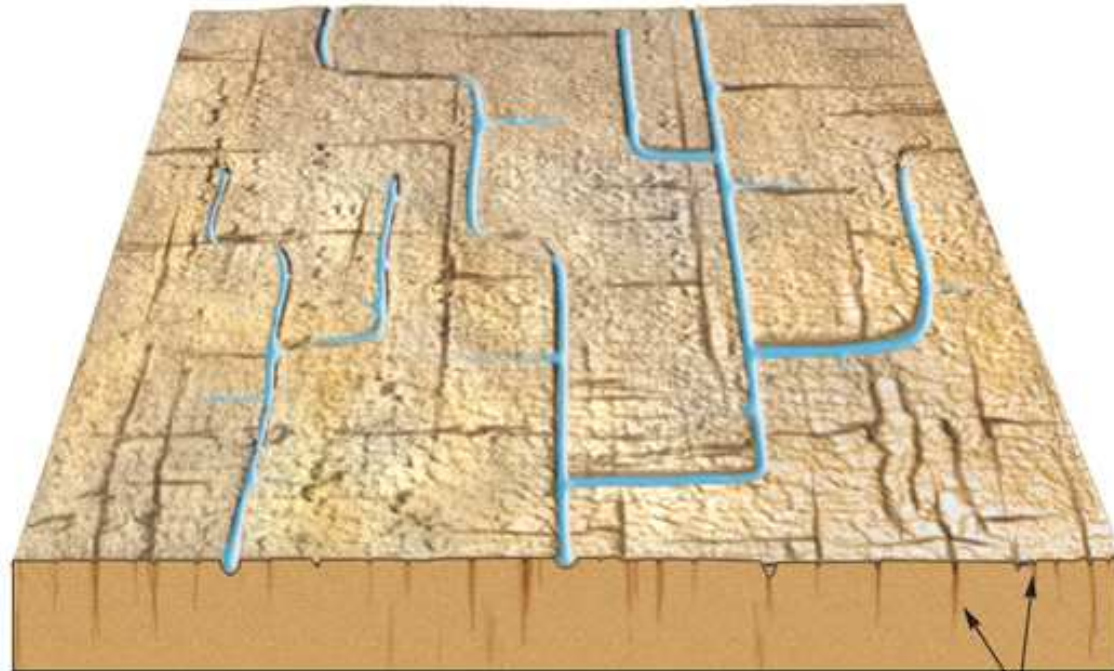
**B** Radial

# Rectangular

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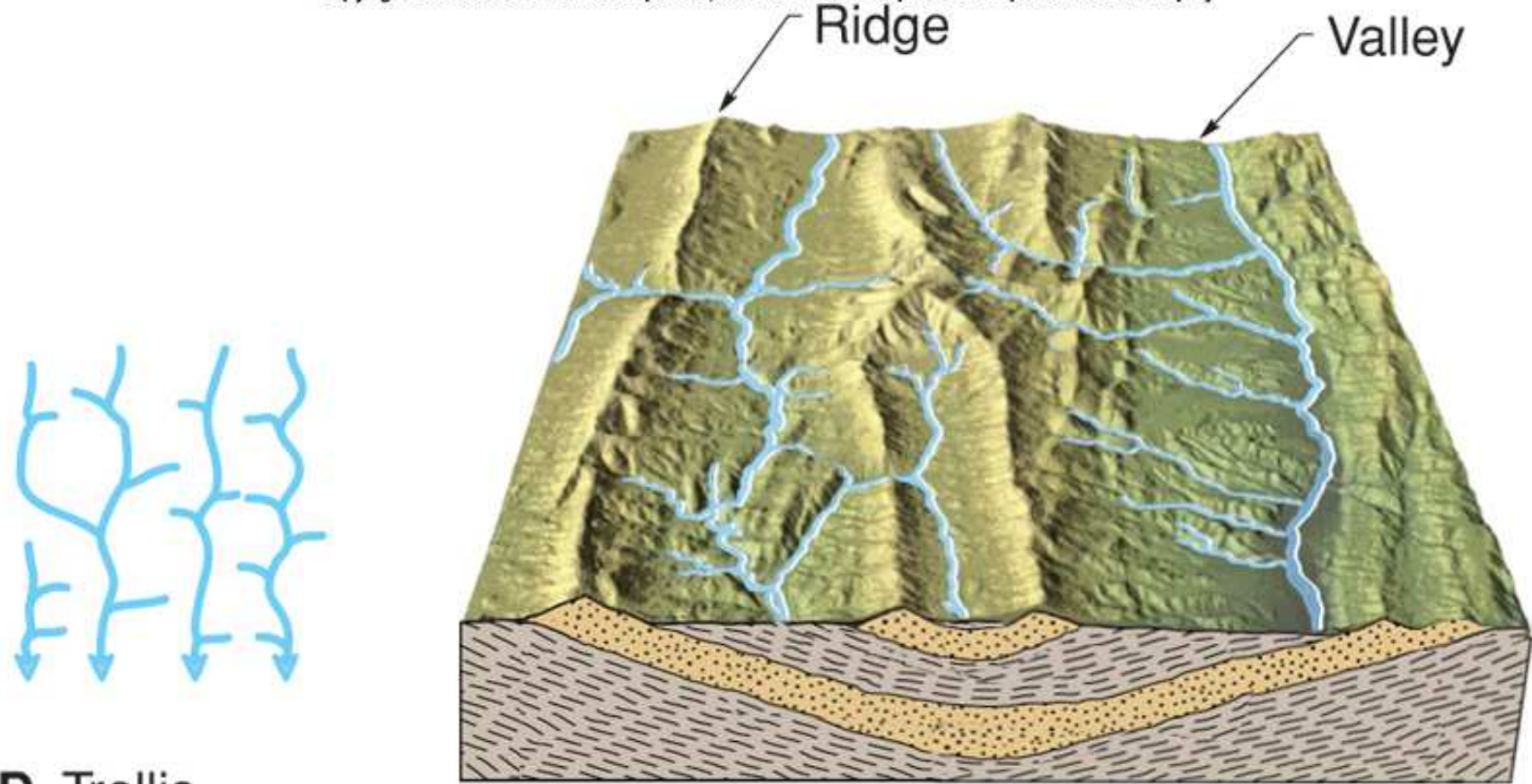
**C** Rectangular



Fractures

# Trellis

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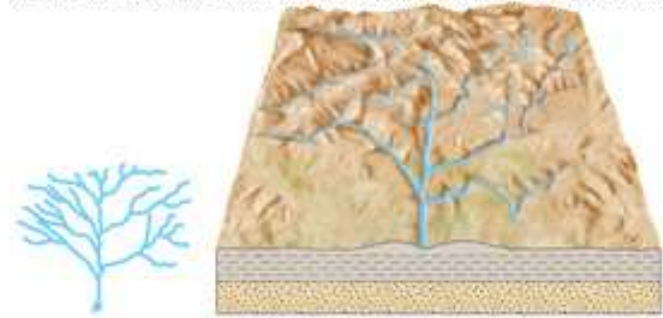


**D** Trellis

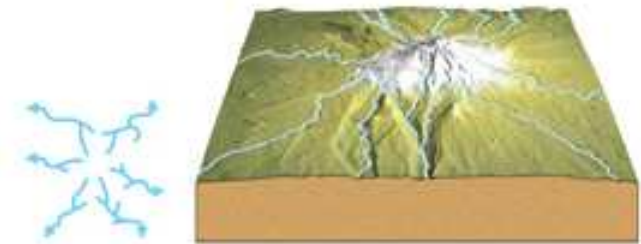
# Drainage Patterns

- Dendritic – uniformly erodible
- Radial – high conical mountains/volcanoes
- Rectangular – regularly fractured rock
- Trellis – alternating resistant vs. nonresistant bed rock (e.g. limestone and shale)

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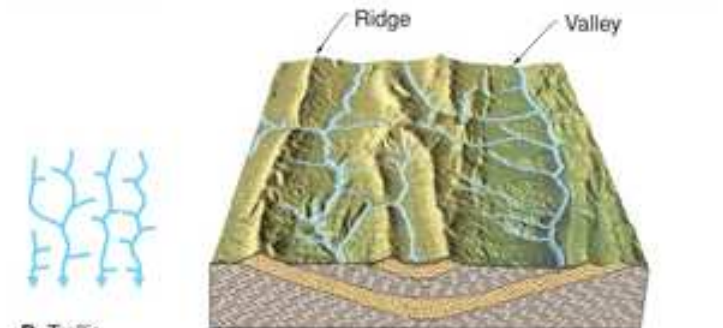
A Dendritic



B Radial



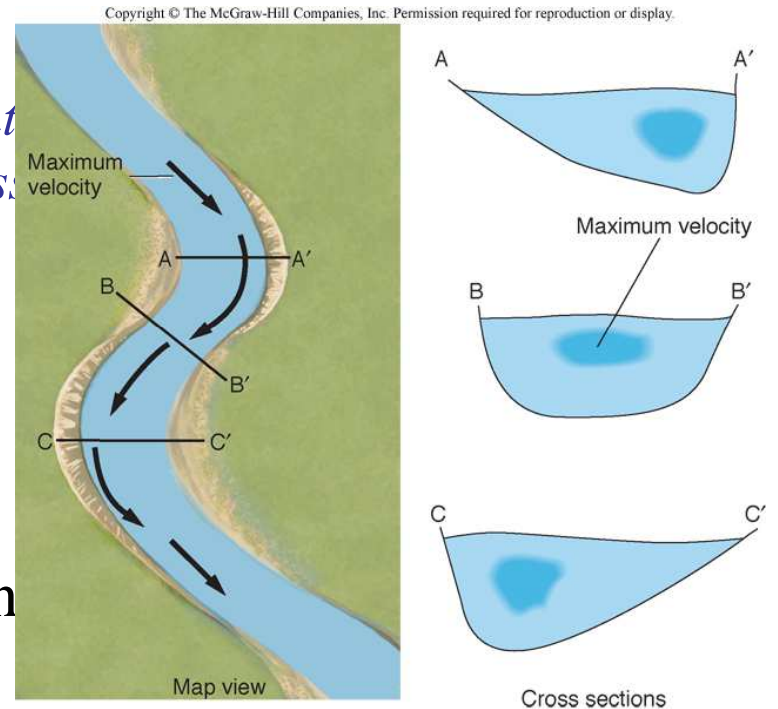
C Rectangular



D Trellis

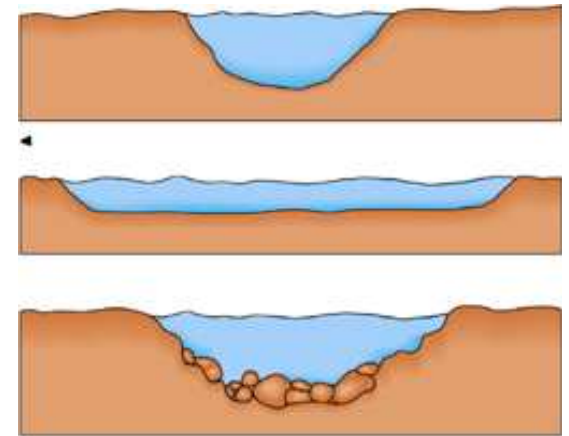
# Stream Erosion

- Stream erosion (and deposition) controlled by flow *velocity* and *discharge*
  - *Stream velocity* controlled by stream *gradient* (slope), *channel shape* and *channel roughness*
    - Maximum velocity near *center* of channel
  - Floods involve increased velocity and *discharge* (volume of water passing a particular point in a stream over time)
- Higher stream velocities promote erosion and transport of coarser sediments

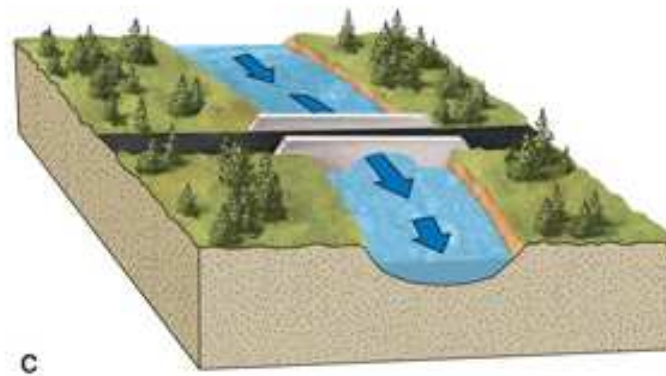
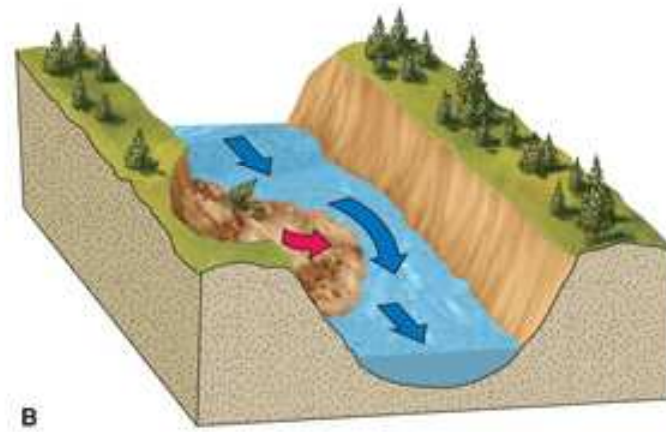
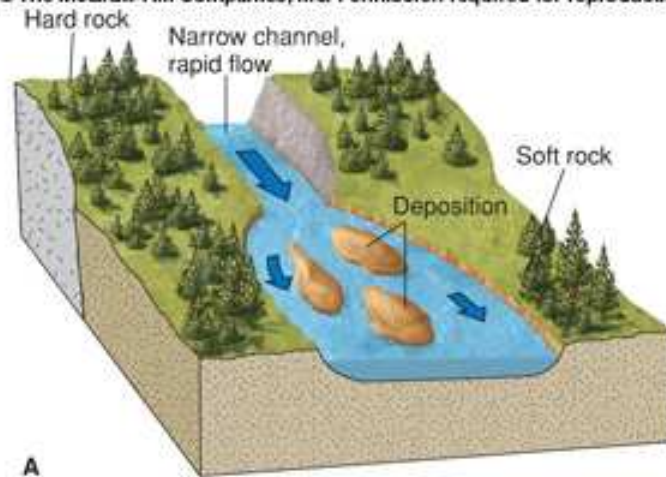


# Stream Erosion

- *Stream gradient* is the downhill slope of the streambed
  - Typically measured in feet per mile in the U.S., and in meters per kilometer elsewhere
  - Usually decreases downstream
- *Channel shape and roughness*
  - Both effect stream velocity due to drag
  - Narrower, deeper channels allow faster flow
  - Smoother channels allow faster flow
  - Wider, shallower channels decrease flow speed
  - Rougher channels decrease flow speed
- Stream *discharge* is the volume of water flowing past a given point in a unit of time

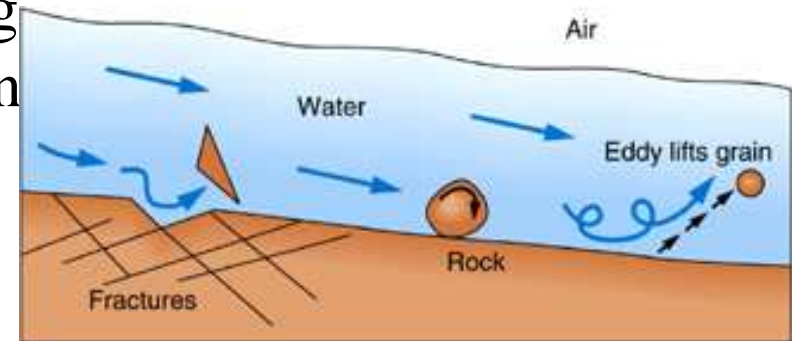


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# Stream Erosion

- Streams cut their own valleys, deepening and widening them over time and carrying away the sediment



- Stream erosion occurs by three mechanisms: *hydraulic action*, *solution*, and *abrasion*
  - *Hydraulic action* - ability of flowing water to pick up and move rock and sediment
  - *Solution* - dissolving of rocks (e.g., limestone)
  - *Abrasion* - grinding away of stream channel by the friction and impact of the sediment load



# Stream Erosion

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A

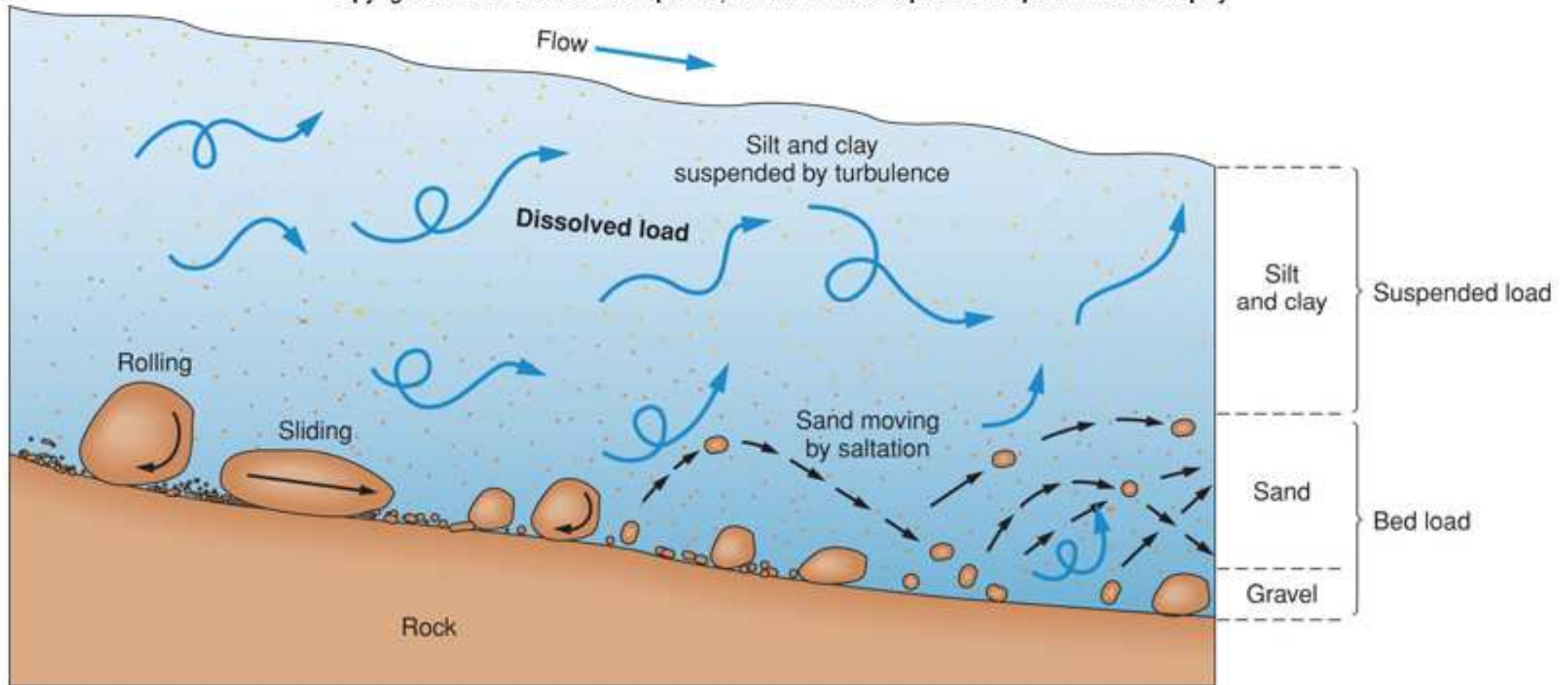
Frank M. Hanna

# Sediment Transportation

- Sediment load transported by a stream can be subdivided into *bed load*, *suspended load*, and *dissolved load*
- *Bed load* - large or heavy particles that travel on the streambed
  - *Traction load* - large particles that travel along the streambed by rolling, sliding or dragging
  - *Saltation load* - medium particles (typically sand-sized) that travel downstream by bouncing along - sometimes in contact with the streambed and sometimes suspended in the flowing water
- *Suspended load* - sediment that is small/light enough to remain above the stream bottom by turbulent flow for an indefinite period of time
- *Dissolved load* - dissolved ions produced by chemical weathering of soluble minerals upstream

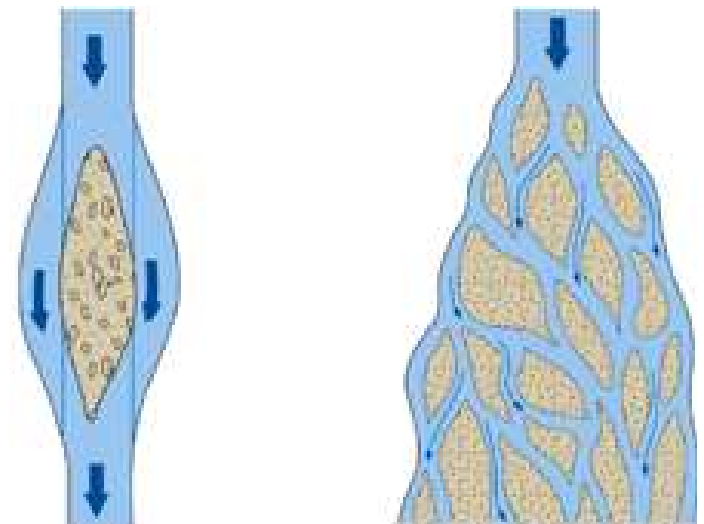
# Stream Transportation of Sediment

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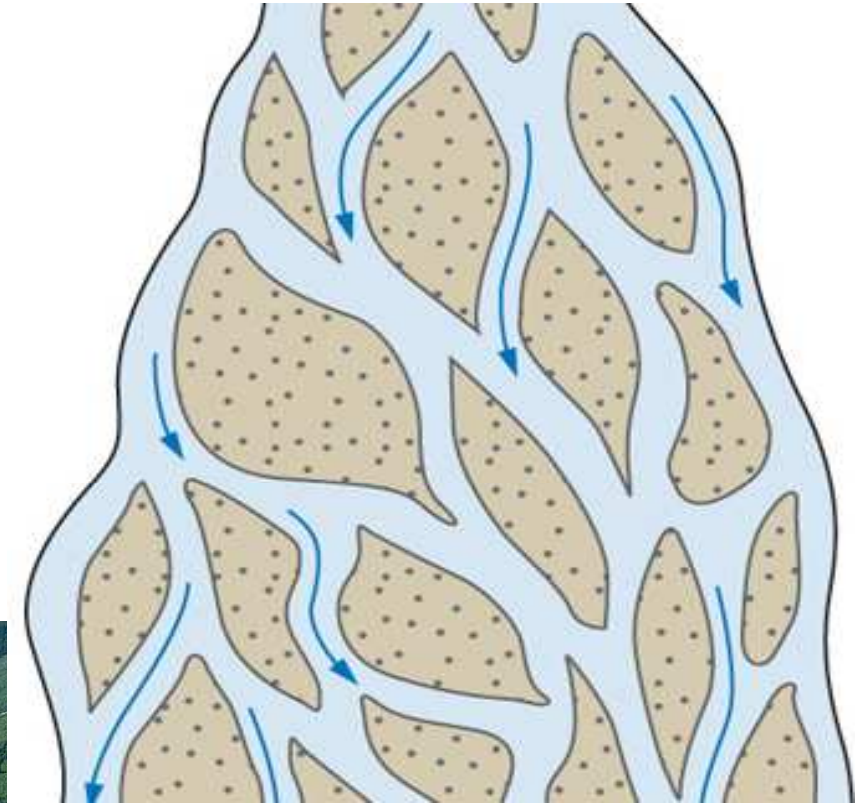


# Sediment Deposition

- Sediments are temporarily deposited along stream course as *bars* and *floodplain deposits*, and at/near its end as *deltas*
- *Bars* - ridges of sediment (usually sand or gravel) deposited in the middle or along the sides of a stream
  - *Braided streams* contain sediment deposited as numerous bars around which water flows in highly interconnected streams



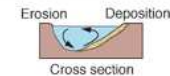
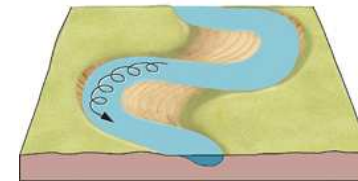
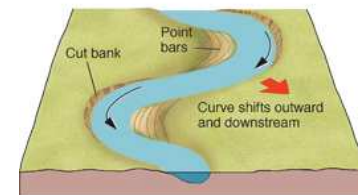
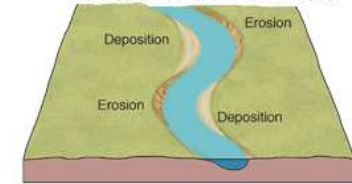
# Braided Streams



# Sediment Deposition

- *Meandering streams* flow faster along the outside of bends and more slowly along the inside, depositing *point bars* on the insides of the meanders
- *Meander cutoffs (Oxbow lake)* may form when a new, shorter channel is cut through the narrow neck of a meander (as during a flood)

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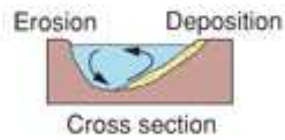
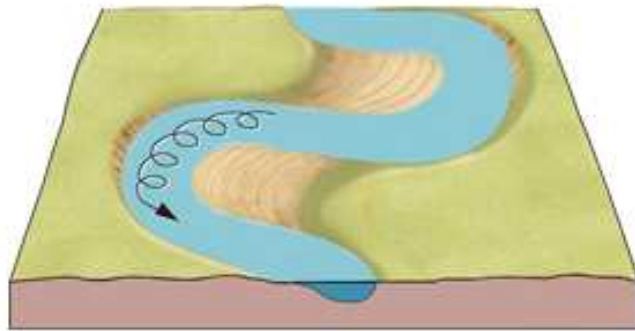
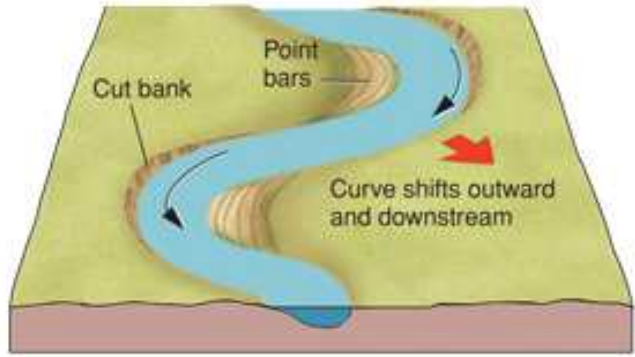
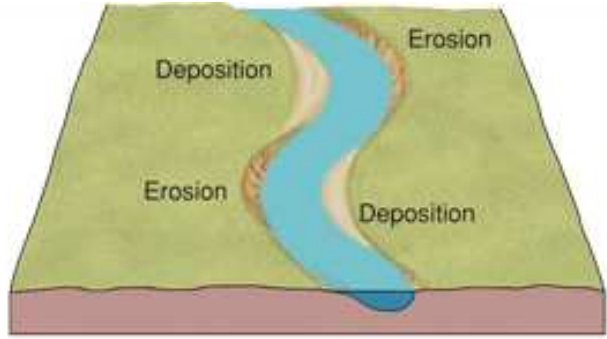


Corkscrew water motion on a curve helps cause erosion and deposition.

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Corkscrew water motion on a curve helps cause erosion and deposition

# Oxbow Lake

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Meander neck  
becomes narrower

Neck cutoff  
occurs

Oxbow lake



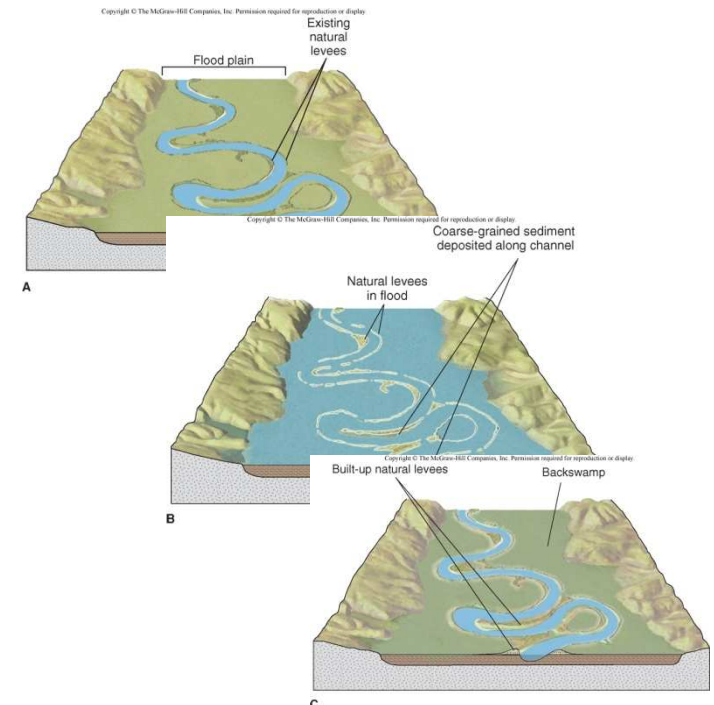
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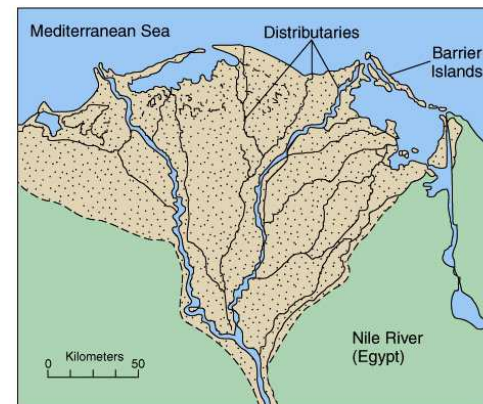
# Sediment Deposition

- *Floodplains* are broad strips of land built up by sedimentation on either side of a stream channel
  - *Floodplain sediments* are left behind as flood waters slow and recede at the end of flood events
  - Main channel has slightly raised banks with respect to the floodplain known as *natural levees*

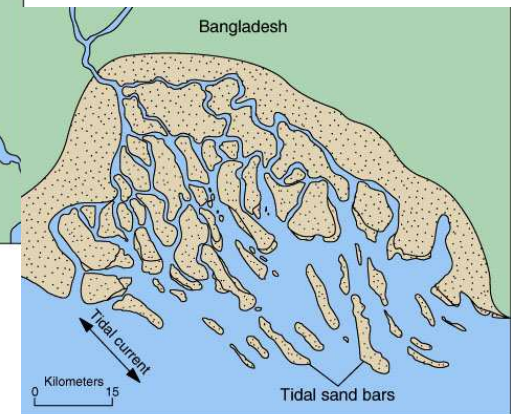


# Sediment Deposition

- *Delta* - body of sediment deposited at the mouth of a river when flow velocity decreases
  - Surface marked by shifting *distributary* channels
  - Shape of a delta depends on whether its *wave-dominated*, *tide-dominated*, or *stream-dominated*



A Wave-dominated delta



B Tidal-dominated delta

# Sediment Deposition - Deltas

Stream Dominated  
Mississippi River

vs. Wave Dominated  
vs. Nile River

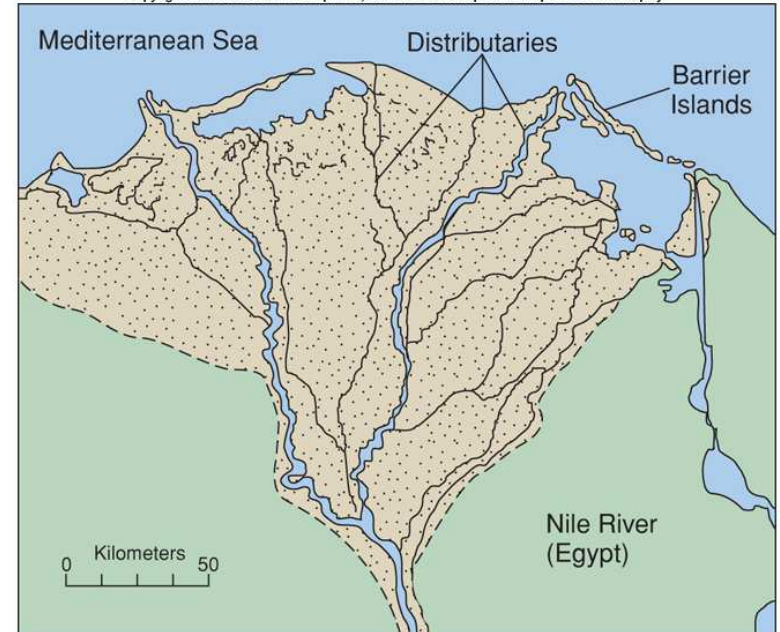
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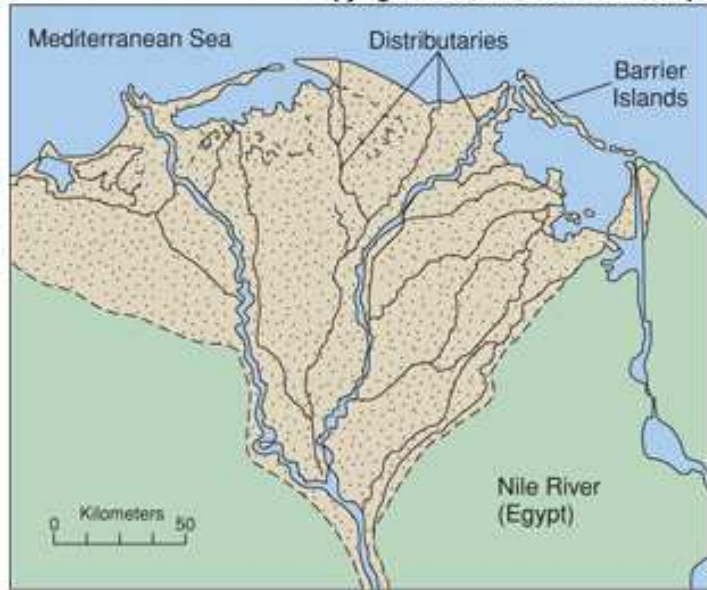
C Stream-dominated delta

NASA

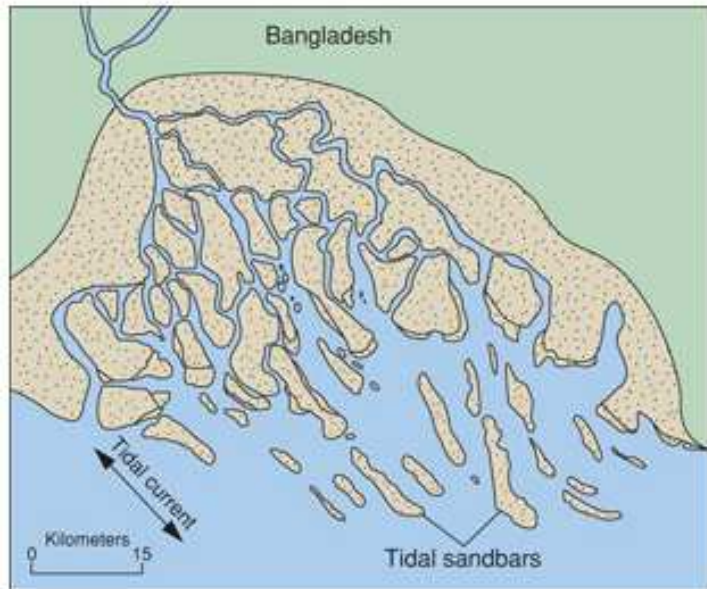
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A Wave-dominated delta



A Wave-dominated delta



B Tidal-dominated delta



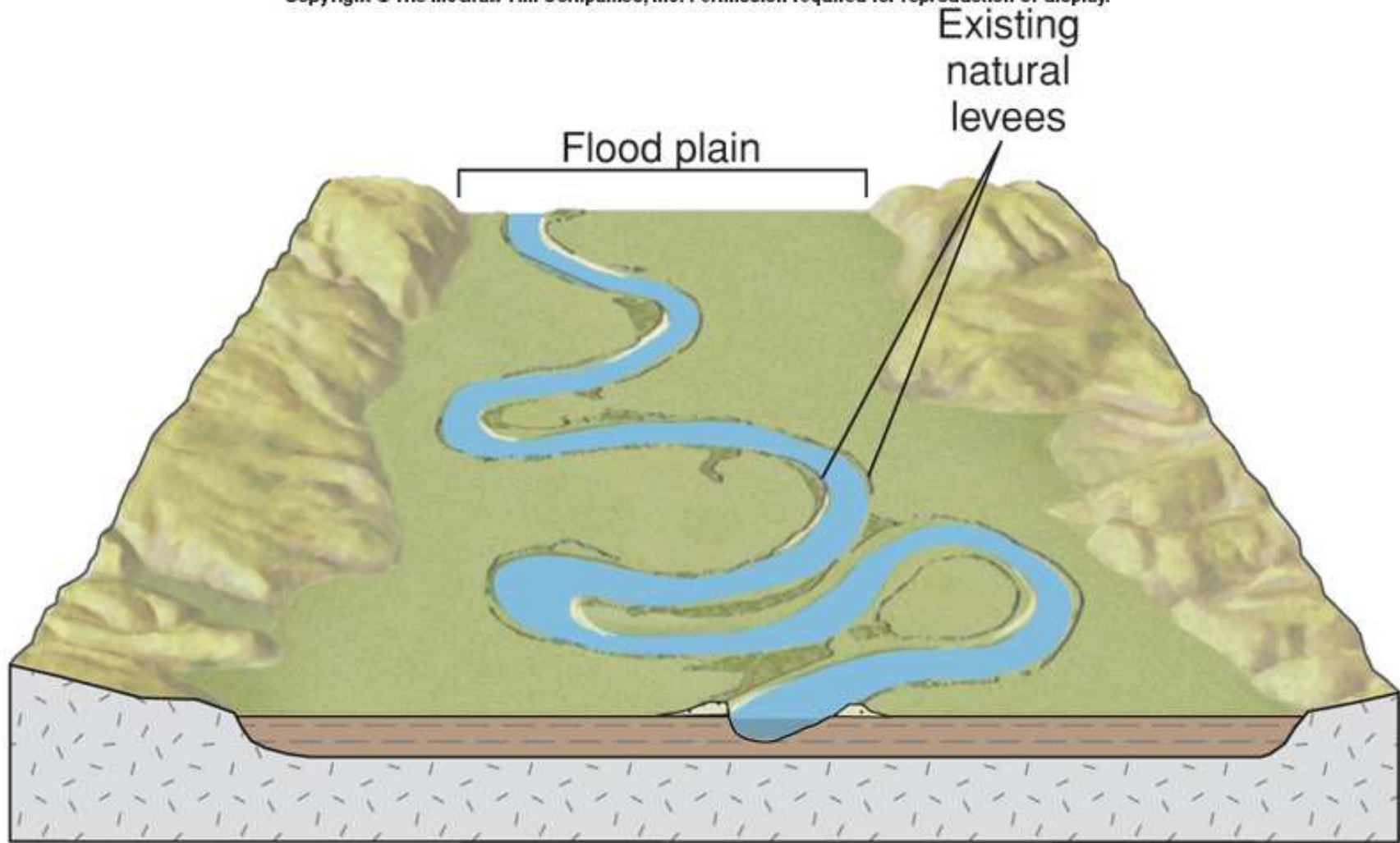
C Stream-dominated delta

# Flooding

- When water levels rise and overtop the banks of a river, *flooding* occurs
  - Natural process on *all* rivers
  - Can cause *great damage* in heavily populated areas
  - High velocity and large volume of water causes *flood erosion*
  - Slowing of waters as flood ends causes *flood deposits* (usually of silt or clay-sized particles) to be deposited in the floodplain



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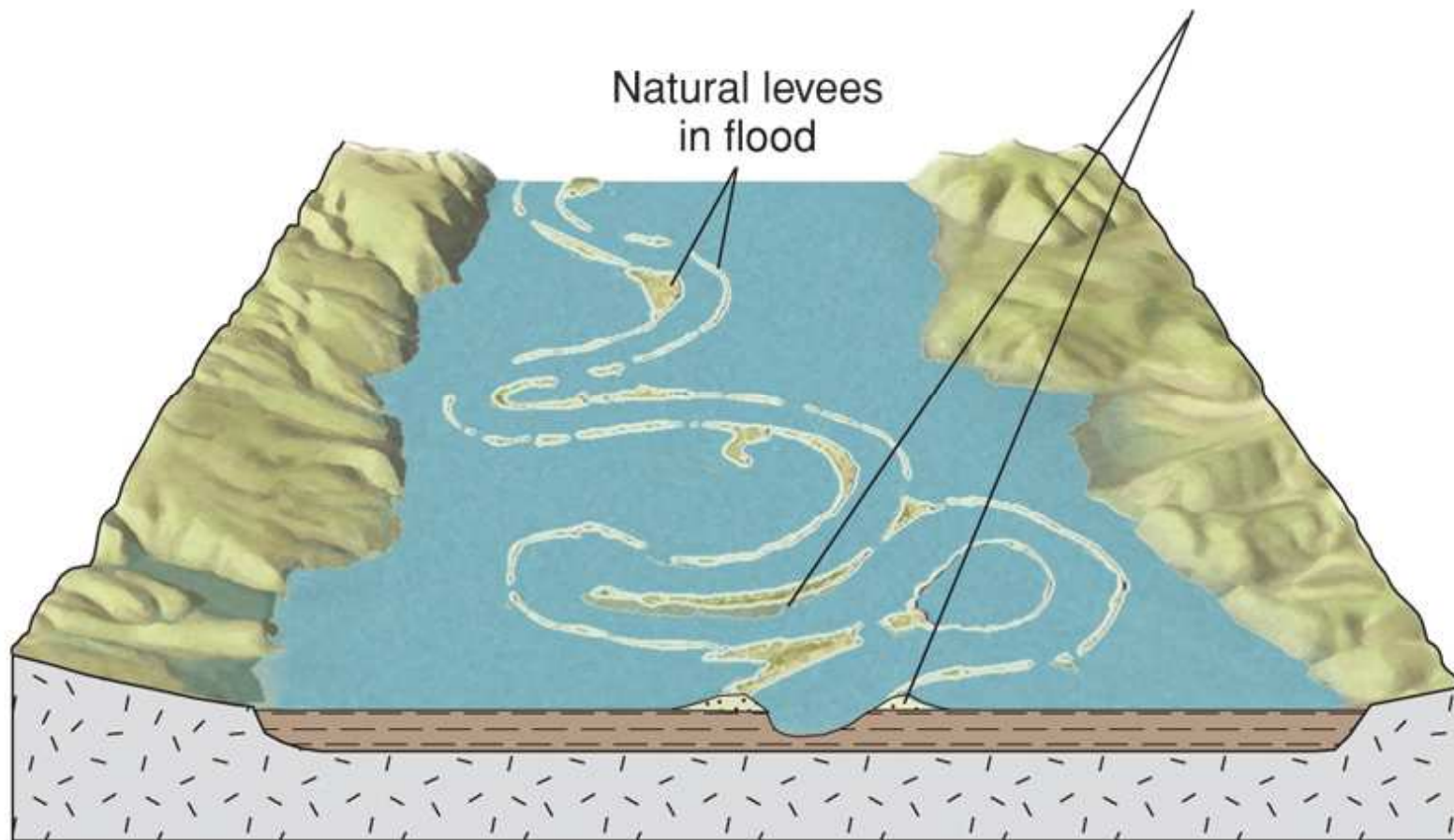


**A**

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Coarse-grained sediment  
deposited along channel

Natural levees  
in flood

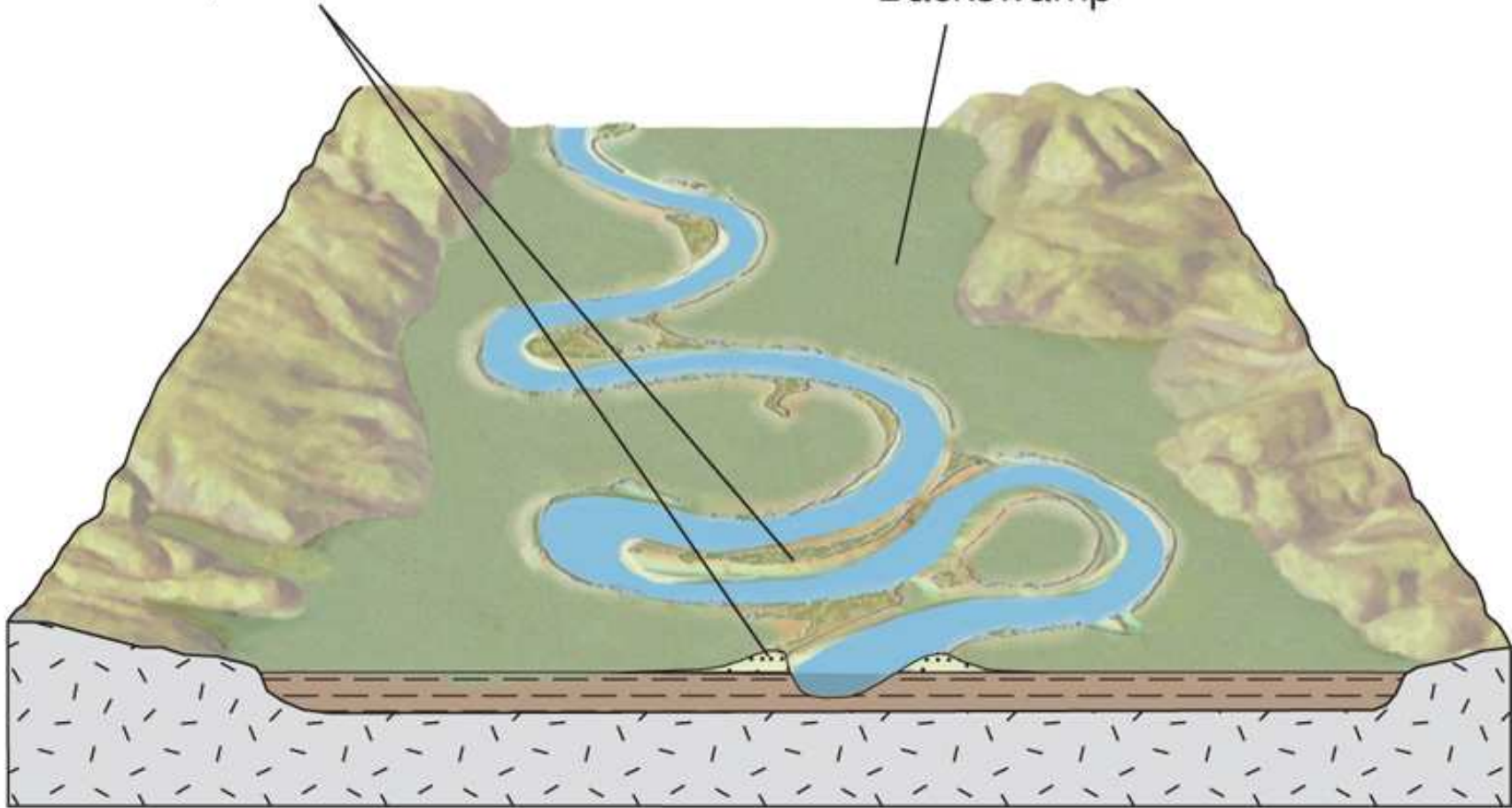


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Built-up natural levees

Backswamp



C

# 1993 Flood



A

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A

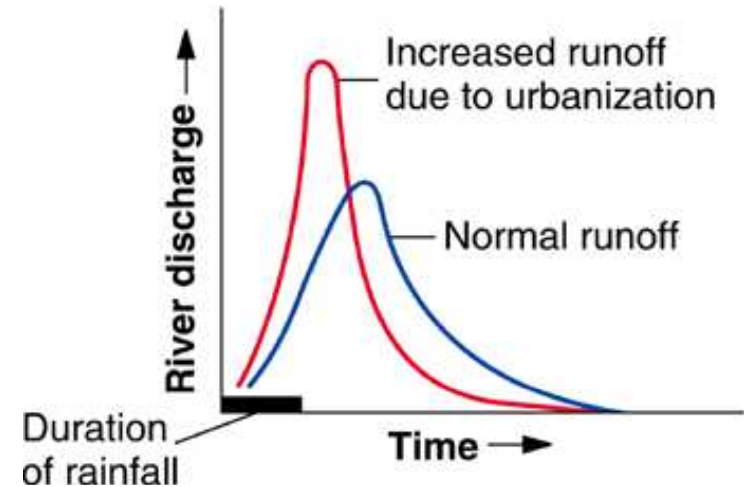


B

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# Flooding

- *Urban flooding*
  - Paved areas increase runoff by inhibiting infiltration
  - Rapid delivery of water to streams increases peak discharge and accelerates occurrence of flood
- *Flash floods*
  - Local, sudden floods of large volume and short duration
  - Typically triggered by heavy thunderstorms



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courtesy of Robert A. Eplett, Governor's Office of Emergency Services

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B

W. R. Hansen, U.S. Geological Survey

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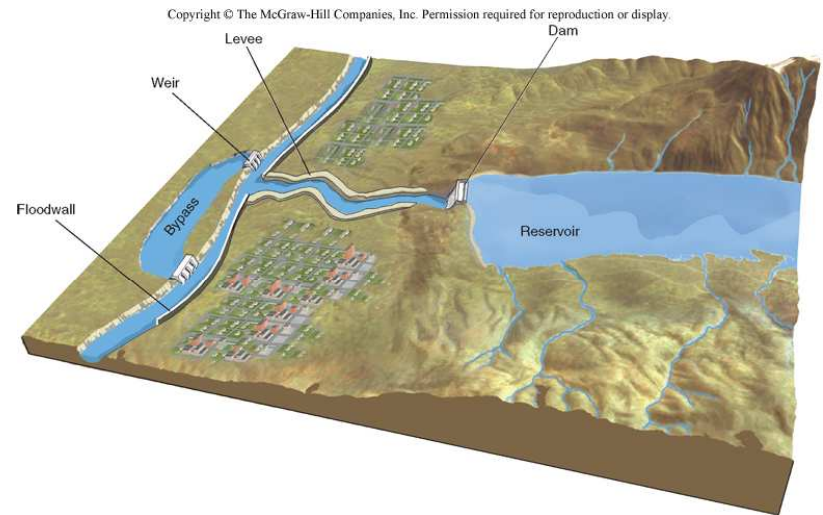


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W. R. Hansen, U.S. Geological Survey

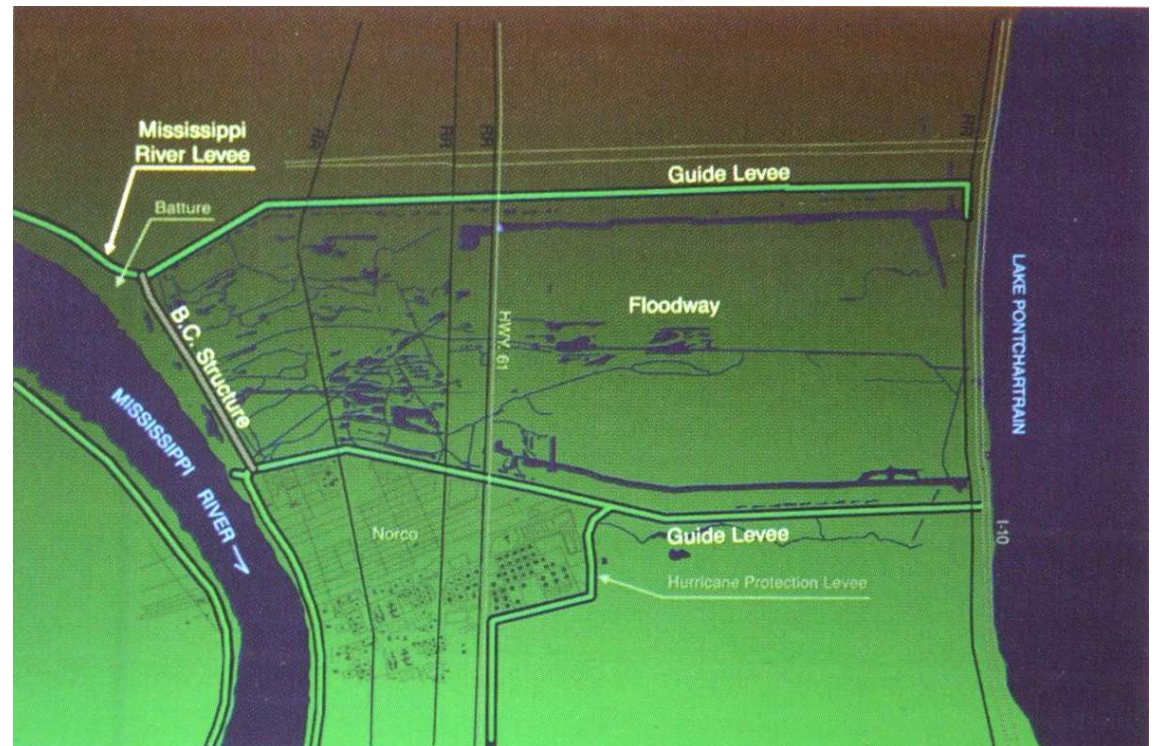
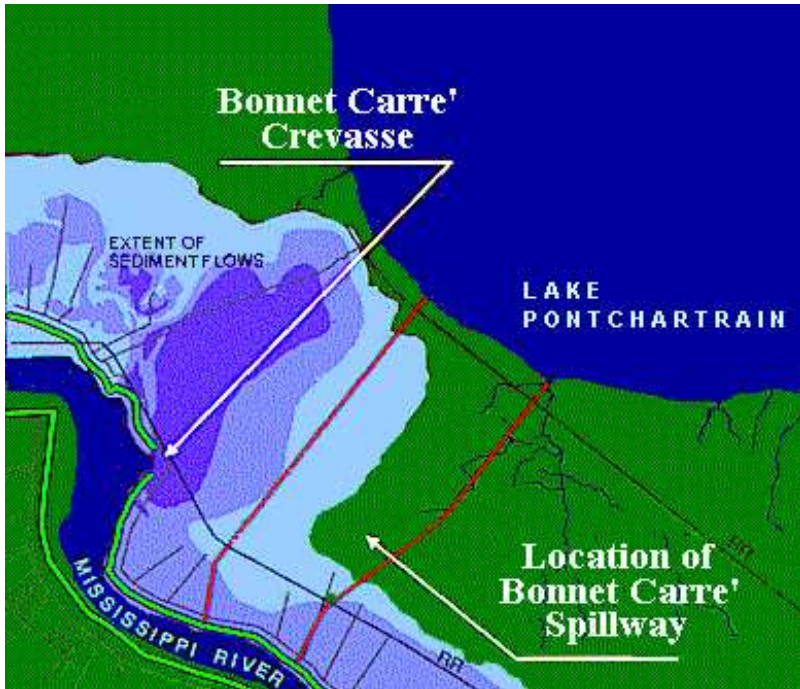
# Flooding

- *Flood control*
  - *Dams* designed to trap flood waters in reservoirs upstream and release it gradually over time
  - *Artificial levees* designed to increase capacity of river channel
    - Works well until stream overtops artificially raised levees, leading to extremely rapid flooding and erosion
  - *Wise land-use planning*, including prevention of building within 100-year floodplains, is most effective





# Bonnet Carre' Spillway



# Mississippi River Delta Plain Coastal Zone





Bonne Carre



Bonne Carre

# Effect of Bonnet Carre Spillway Opening



# Photograph vs. Suspended Sediment Map



Comparison of a photograph of the Lake Pontchartrain acquired on April 29, 2008 by astronauts on board the International Space Station to a suspended sediment map generated using MODIS image.

**End of Chapter 16**