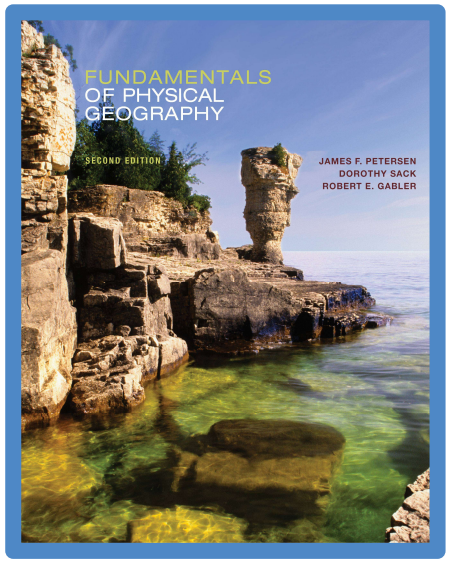
Fundamentals of Physical Geography 2e

Fluvial Processes and Landforms

14



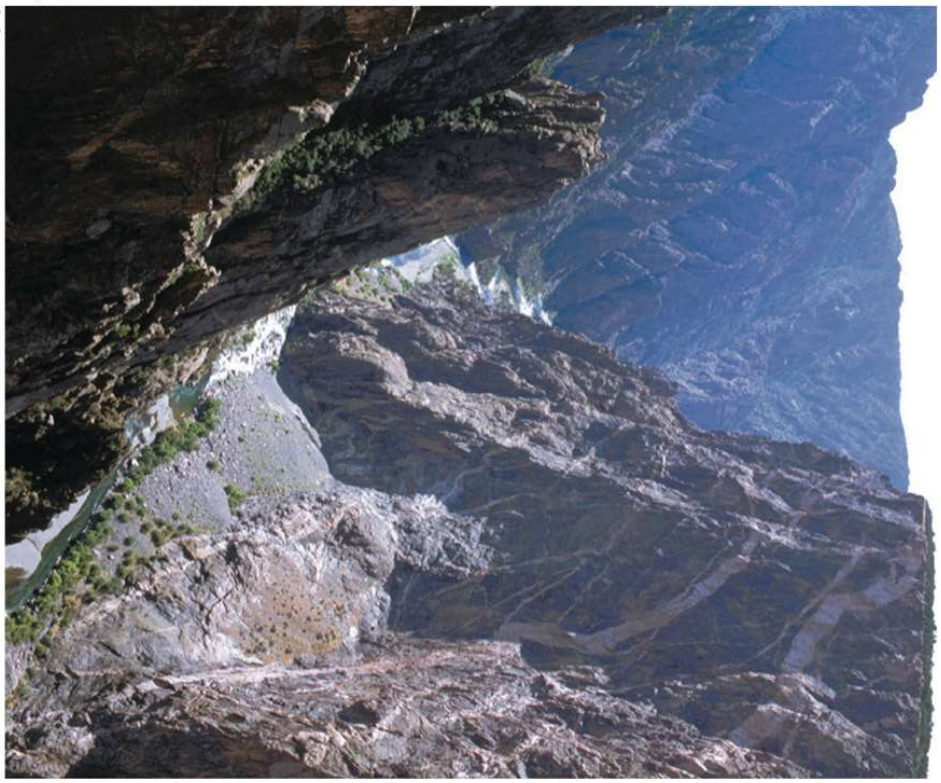
- Peterson
  - Sack
    - Gabler

Introduction

- Fluvial geomorphology
  - Study of flowing water as a land-shaping process and study of the resulting landforms
- Stream
  - Natural channelized flow
- Interfluve
  - Land between channels

L. Lynch/National Park Service

(a)

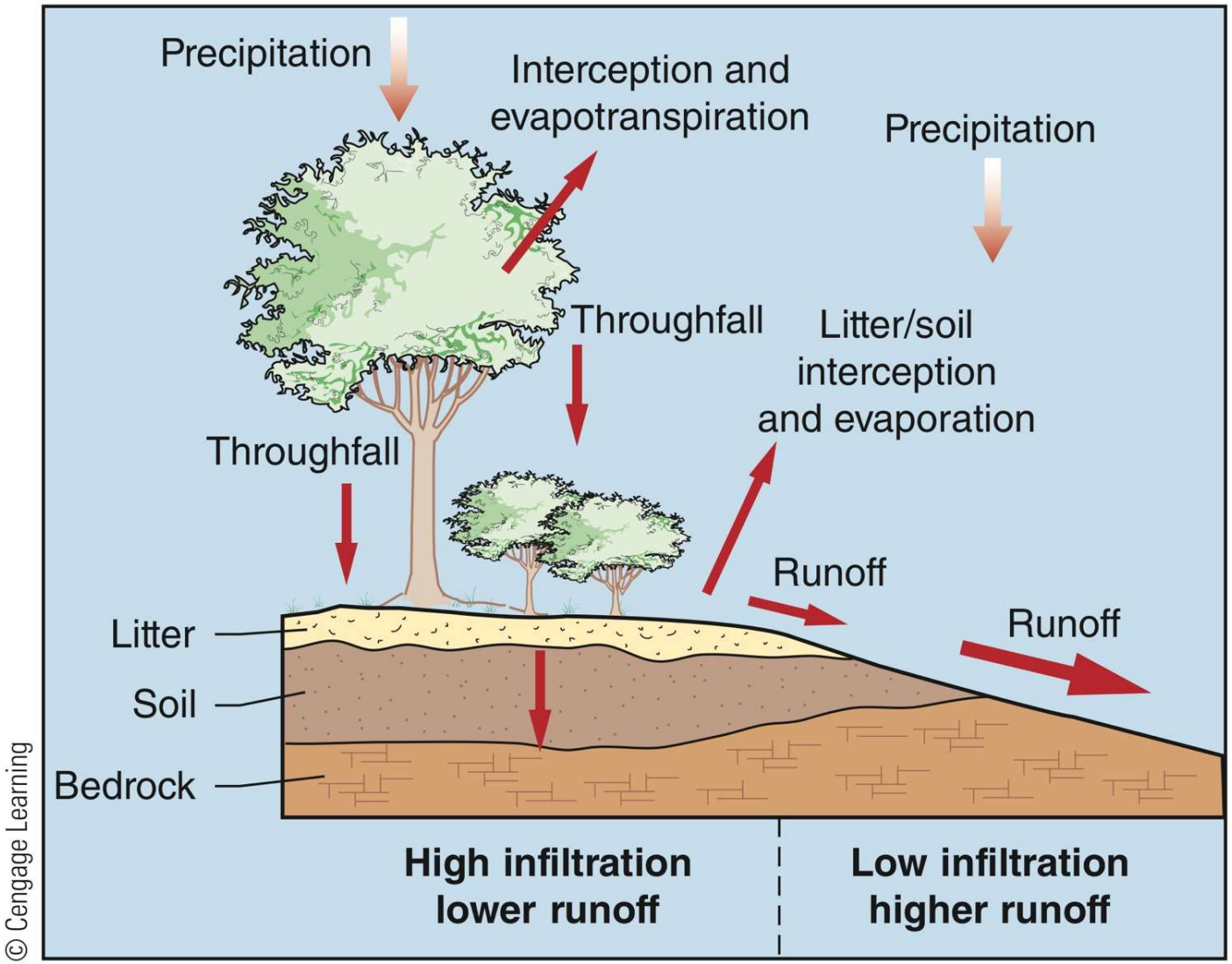


NASA Earth Observatory/Image courtesy NASA/GSFC/METI/ERSDAL/JARDS, and U.S./Japan ASTER Science Team

(b)

Surface Runoff (cont'd.)

- Originating from rainfall
  - Precipitation exceeds the ability of the ground to soak up the moisture
- Factors impacting surface runoff
  - Precipitation event
  - Infiltration capacity
  - Interception of precipitation by vegetation
  - Transpiration
  - Human activities



What are some ways that vegetation influences infiltration and runoff?

Surface Runoff (cont'd.)

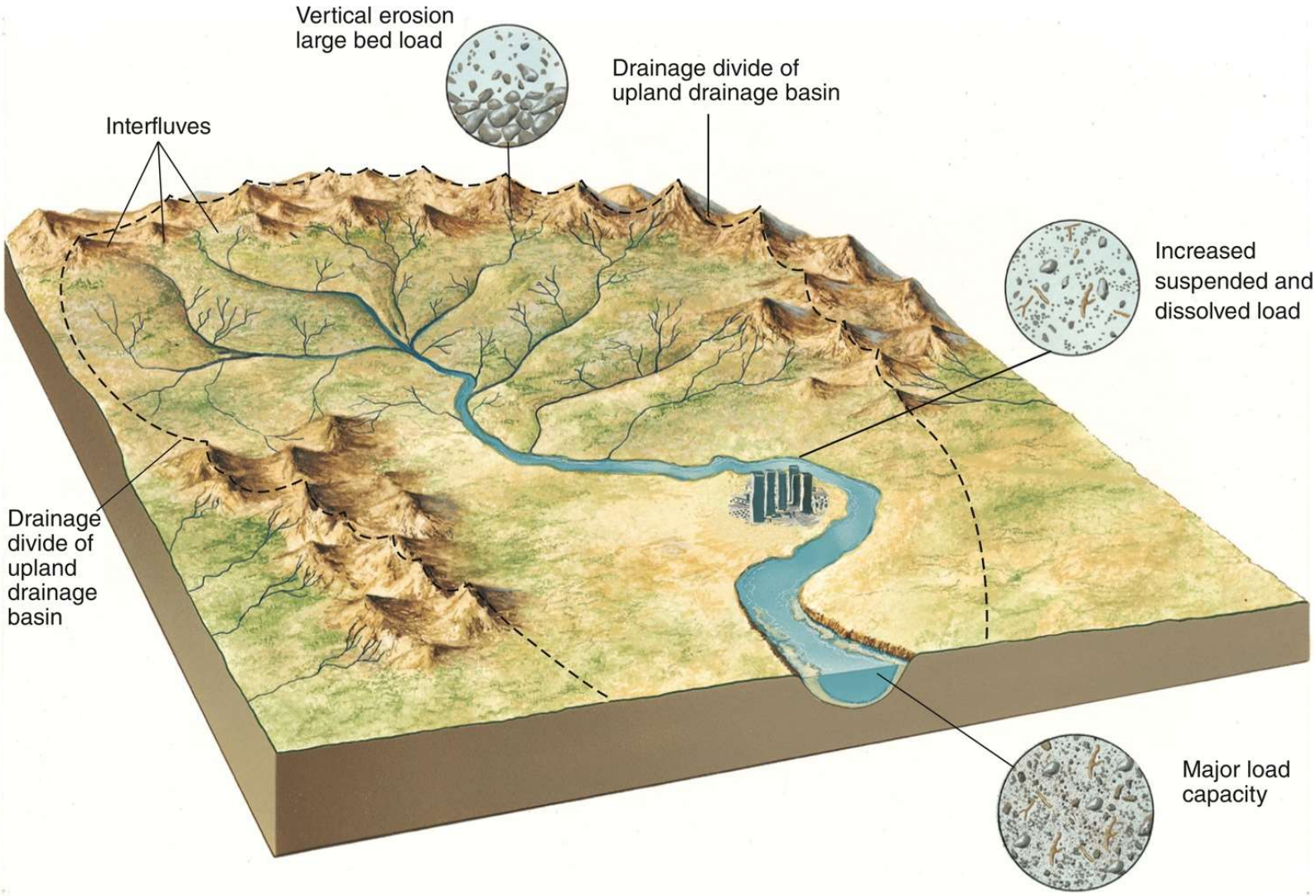
- Characteristics
  - First starts to flow downslope (sheet wash)
  - Flow is concentrated due to gravity
    - Rills
    - Gullies
  - Ephermeral flow
  - Perennial flow
    - How is it possible for perennial streams to continue to flow even without recent rainfall?

D. Sack

Are any gullies visible in this photo?

The Stream System

- Channel systems
  - Small perennial channels join making larger perennial channels
    - Larger perennial channels join creating even bigger streams
  - Tributaries
  - Trunk stream



The Stream System (cont'd.)

- Drainage basin: watershed or catchment
  - Expanse of land provides runoff to a stream
  - What are the units of measure when referring to a drainage area?
  - Subbasins
  - Open systems: inputs and outputs
    - Water, sediment, and energy
  - Drainage divide: outside perimeter
    - The Continental Divide

Texas Natural Resources Information System

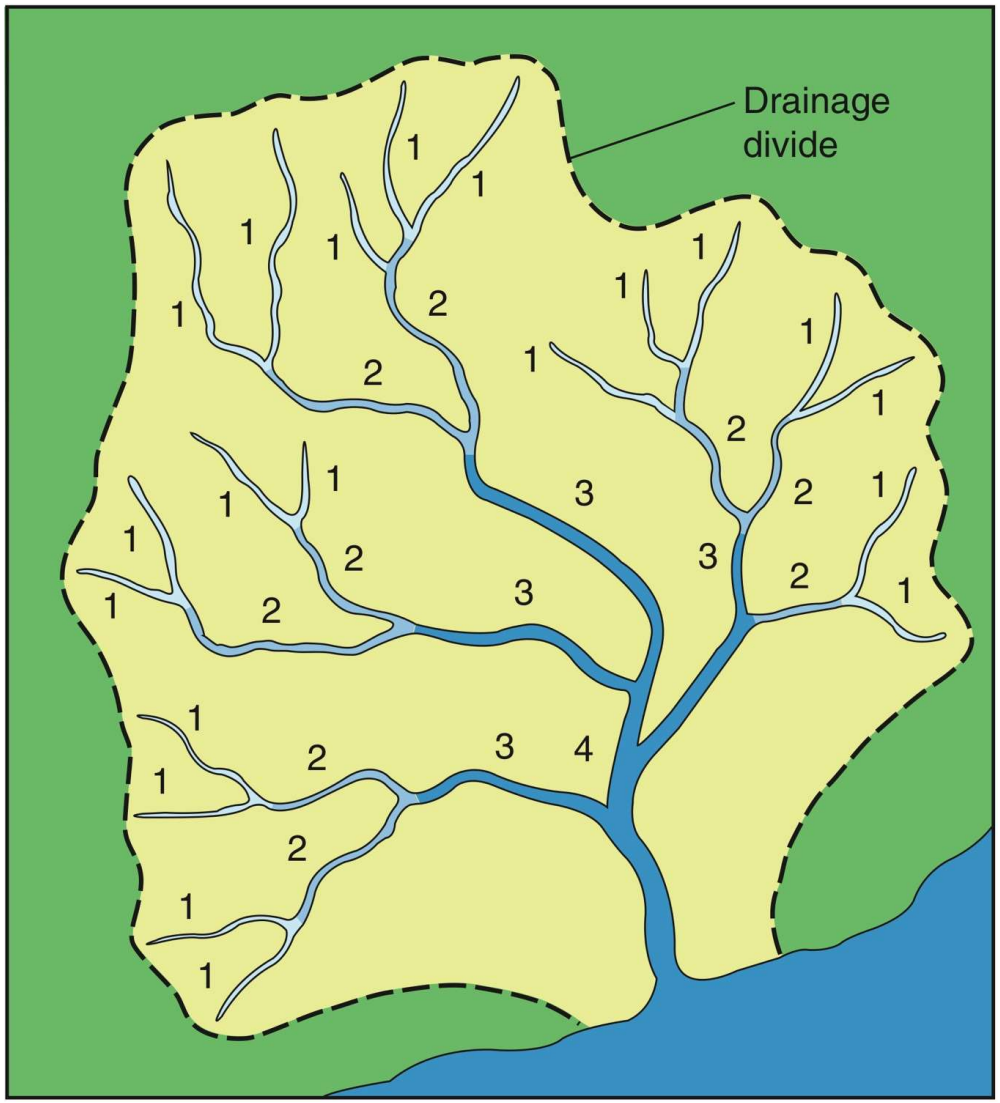
Can you count the number of drainage divides appearing in this photo?

Major Perspectives in Physical Geography (cont'd.)

- Drainage basins as critical natural regions
  - Dividing Earth's land surface by drainage basins
    - Interrelated components
    - Channel network
    - Natural biotic habitats
  - Maintaining water quality
  - Watersheds
    - Need for environmental management

The Stream System (cont'd.)

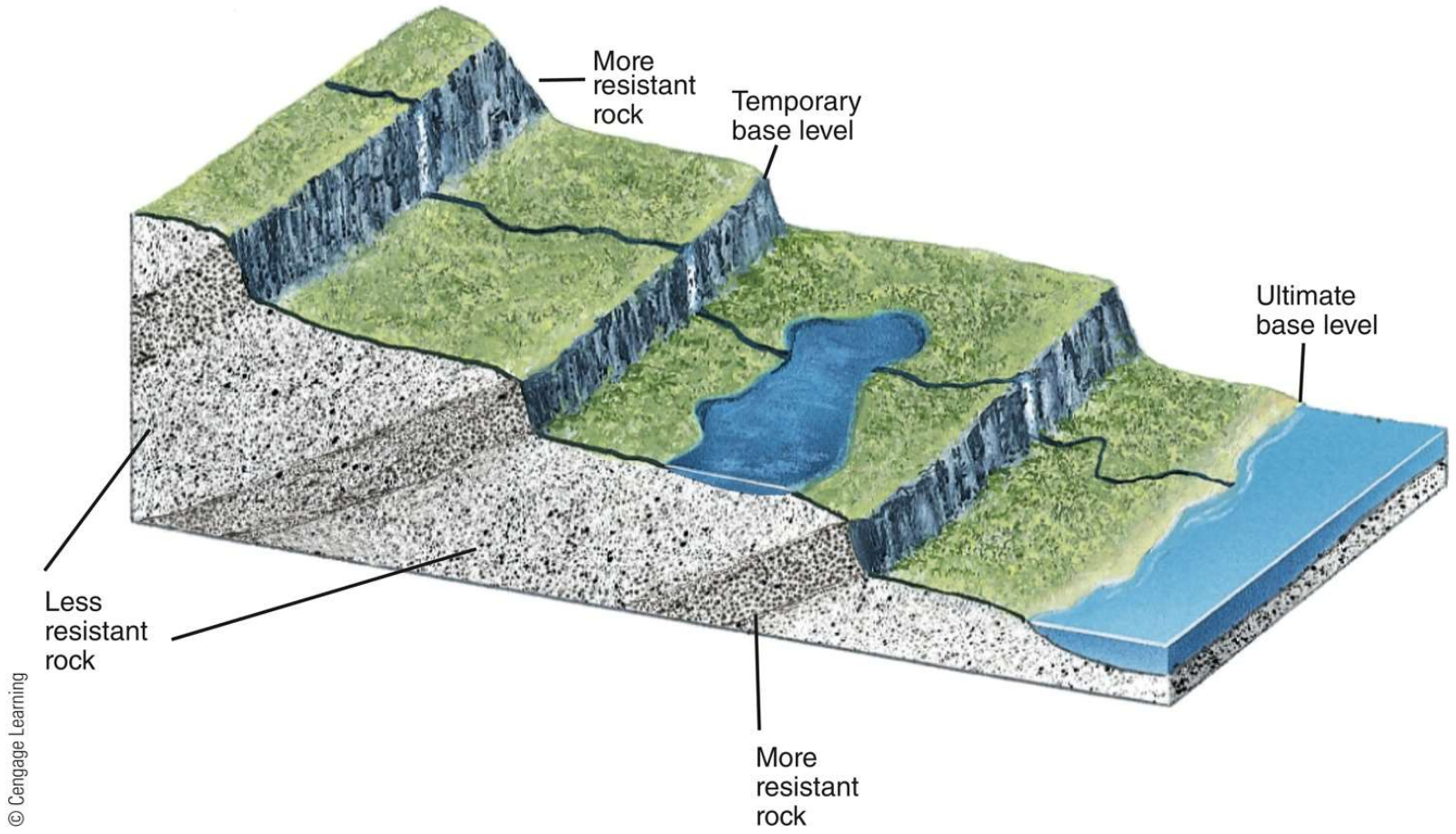
- Stream ordering
  - First-order streams: source area
  - Second-order streams: two first-order streams combined
  - Third-order streams: intersection of two second order channels
  - Mississippi River: tenth-order stream



What is the highest-order stream in a selected drainage basin called?

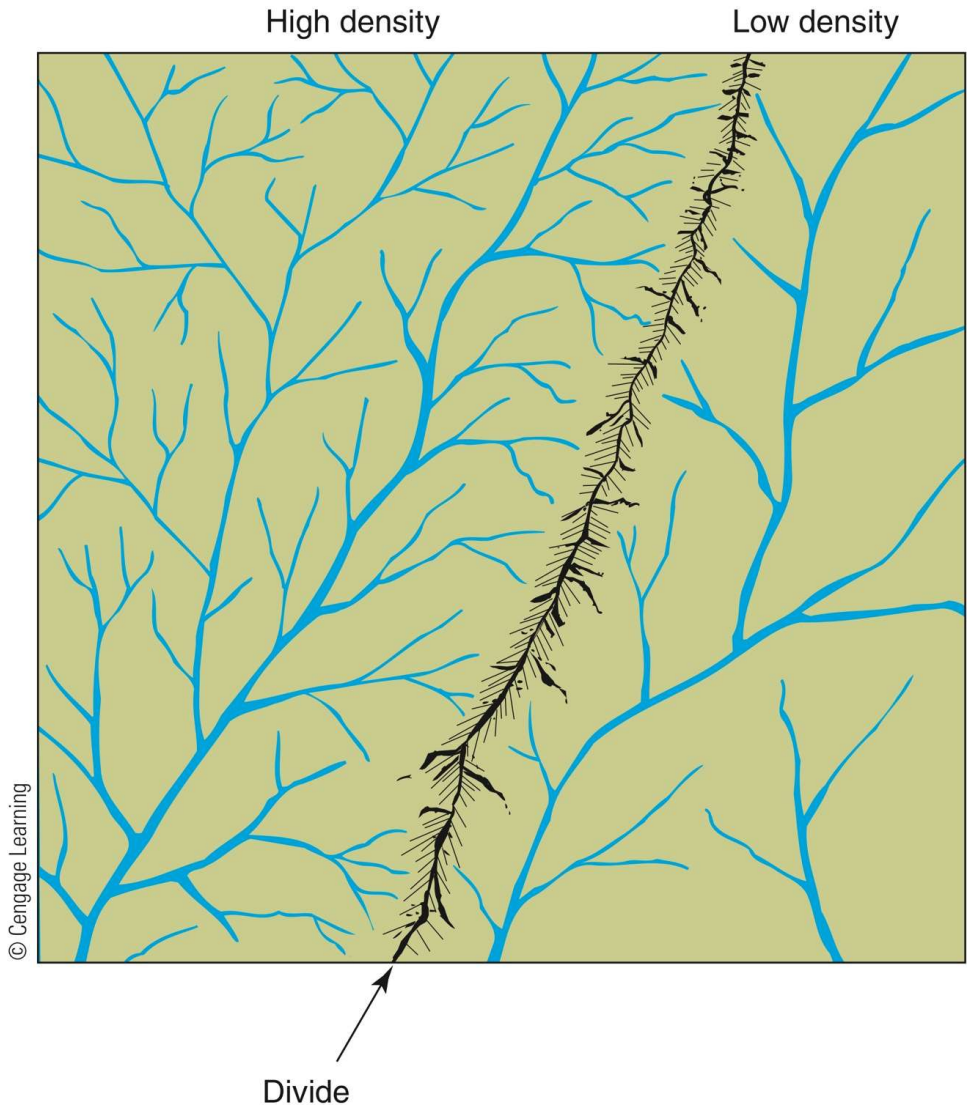
The Stream System (cont'd.)

- Mouth
  - Exterior drainage
  - Interior drainage
- Base level
  - Ultimate base level
  - Regional base level
  - Temporary base level



The Stream System (cont'd.)

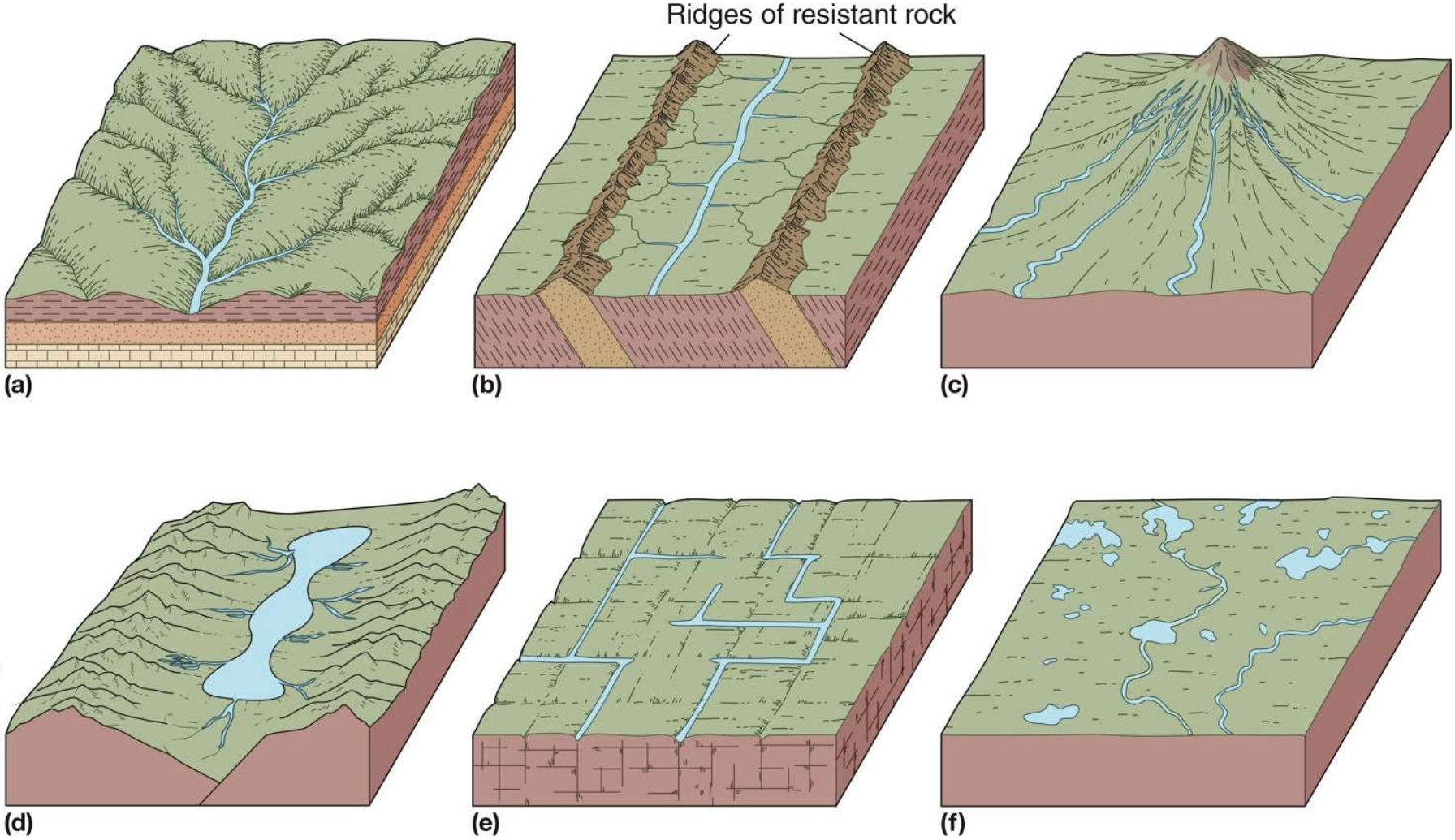
- Drainage density
  - Total length of all channels in a drainage basin divided by its drainage area
  - High drainage densities
    - Limited infiltration, considerable runoff, and moderately erodible surface materials
  - What is the ideal climate for high drainage densities?



What is the relationship between permeability and drainage density?

The Stream System (cont'd.)

- Drainage patterns
  - Networks of stream tributaries display distinct spatial arrangements
  - Factors influencing drainage patterns
    - Bedrock structure
    - Surface topography
  - Types of patterns
    - Dendritic, trellis, radial, centripetal, rectangular, and deranged



Flow Properties (cont'd.)

- Stream discharge (*Q*)
  - Volume of water (*V*) flowing past a given channel cross section per unit time (*t*)*:*

    $Q = V/t$ (units: m^3/s or ft^3/s)
  - Significant runoff
    - Volume (*V*) reaching the channel increases
    - Stream discharge (*Q*) directly proportional to volume (*V*)

Flow Properties (cont'd.)

- Stream discharge *(Q)*
  - Why is it important to collect and analyze discharge data? (Table 14.1)
  - Difficult to measure as: $Q = V/t$
  - Instead calculated by: $Q = Av$ or $Q = wdv$
    - Where A = cross-sectional area, v = average stream velocity, w = channel width, and d = channel depth

J. Petersen

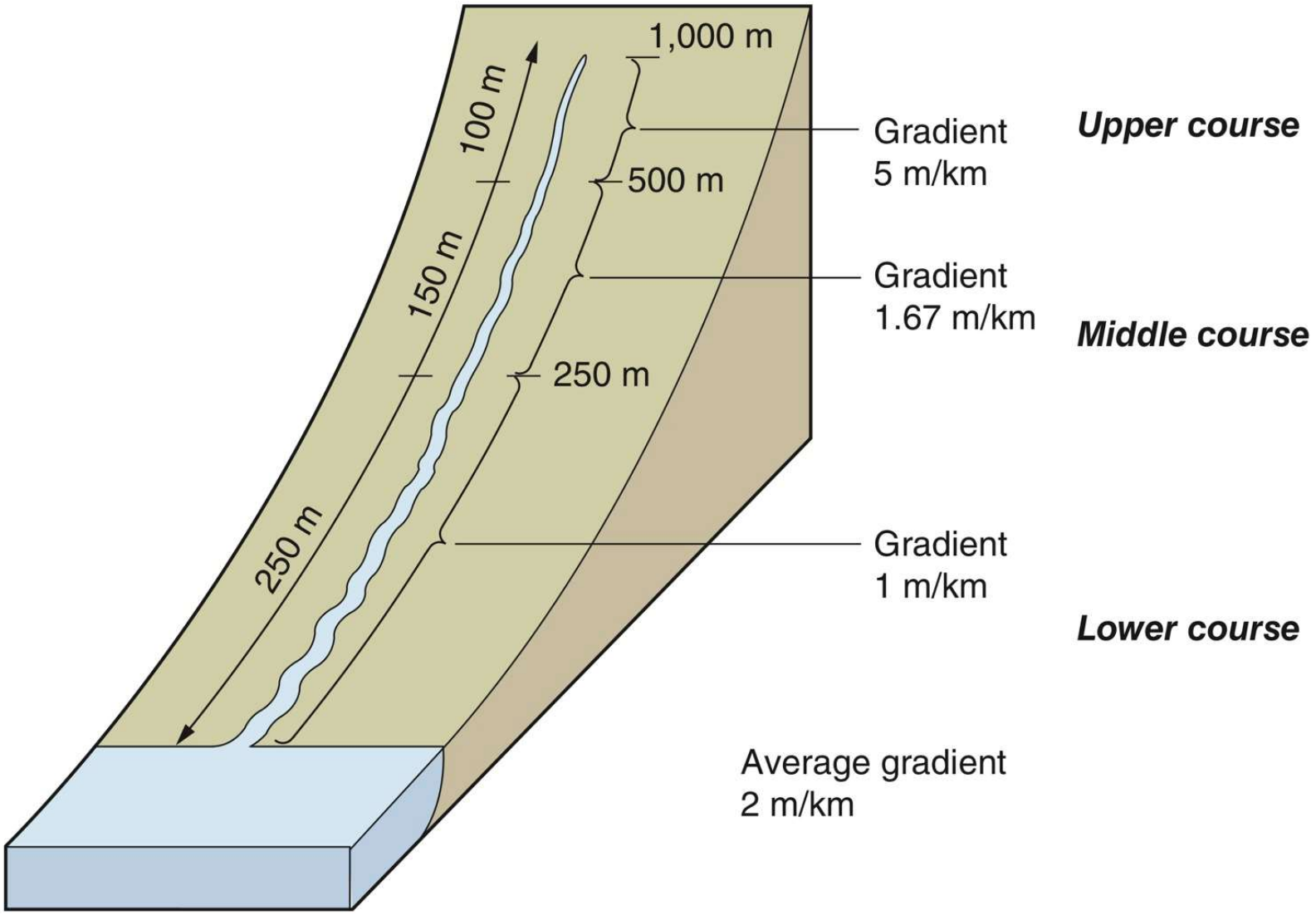
What effect does an increase in stream velocity have on stream discharge?

Flow Properties (cont'd.)

- Stream energy
  - Geomorphic work: depends on kinetic energy
  - Kinetic energy *(E_k):* $E_k = \frac{1}{2} mv^2$, where m = mass and v = velocity
  - Why is stream velocity a critical factor in determining the amount of geomorphic work accomplished?

Flow Properties (cont'd.)

- Stream energy
  - What friction factors slow the stream velocity?
  - Stream gradients
    - Steepest at headwaters and in new tributaries
  - Discharge
    - Increases downstream



Flow Properties (cont'd.)

- Stream energy
  - Stream load
  - Stream competence
  - Stream capacity
  - In what ways do streams have some control over channel size, shape, and gradient?

FEMA/John Shea

Fluvial Processes

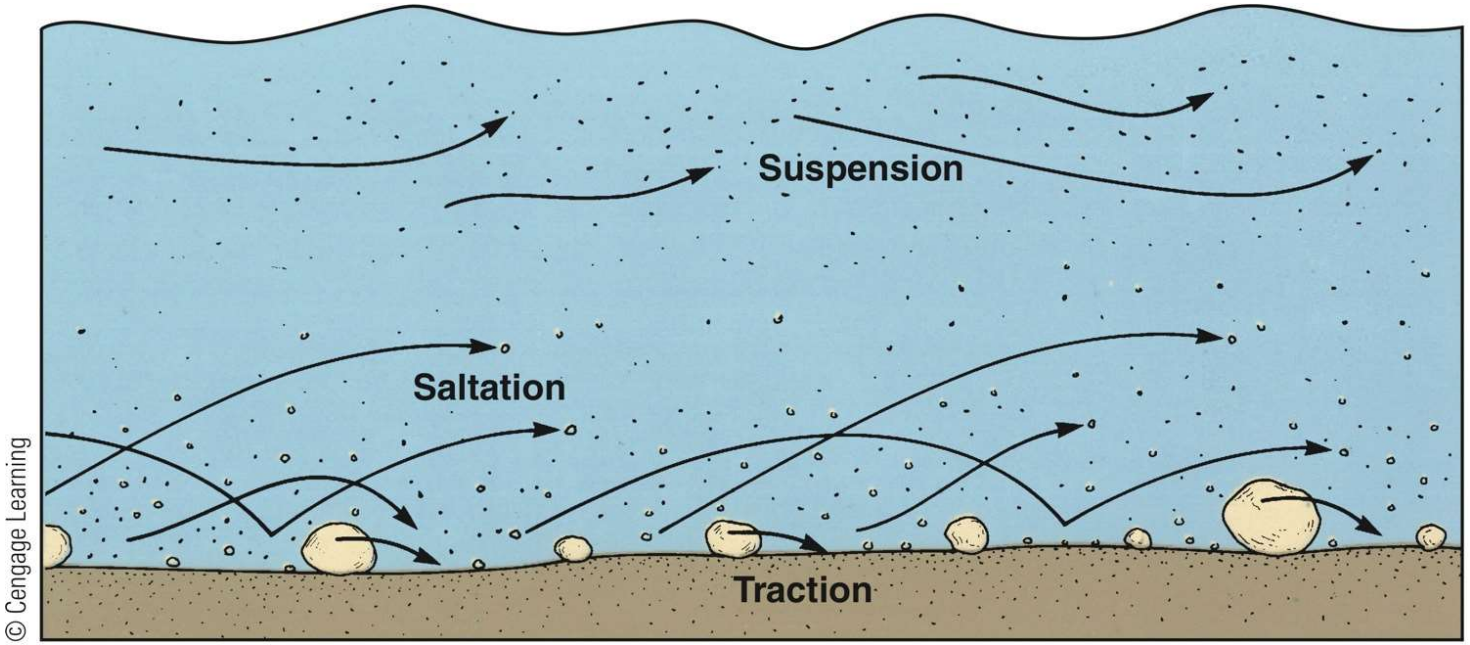
- Stream erosion
  - Fluvial erosion: removal of rock material by flowing water
    - Chemical removal of ions from rocks
    - Physical removal of clasts
  - Channel incision
    - Net erosion compared to deposition
  - Degradation vs. aggradation

Fluvial Processes (cont'd.)

- Stream erosion
  - What is the process of corrosion?
  - Hydraulic action
    - Physical process: stream water removing rock pieces
  - Abrasion
  - Attrition

Fluvial Processes (cont'd.)

- Stream transportation
  - Methods
    - Solution
    - Suspension
    - Saltation
    - Traction
  - Types of stream load
    - Dissolved load
    - Suspended load
    - Bed load
  - What drainage basin characteristics affect the relative proportion of each load type present in a given stream?



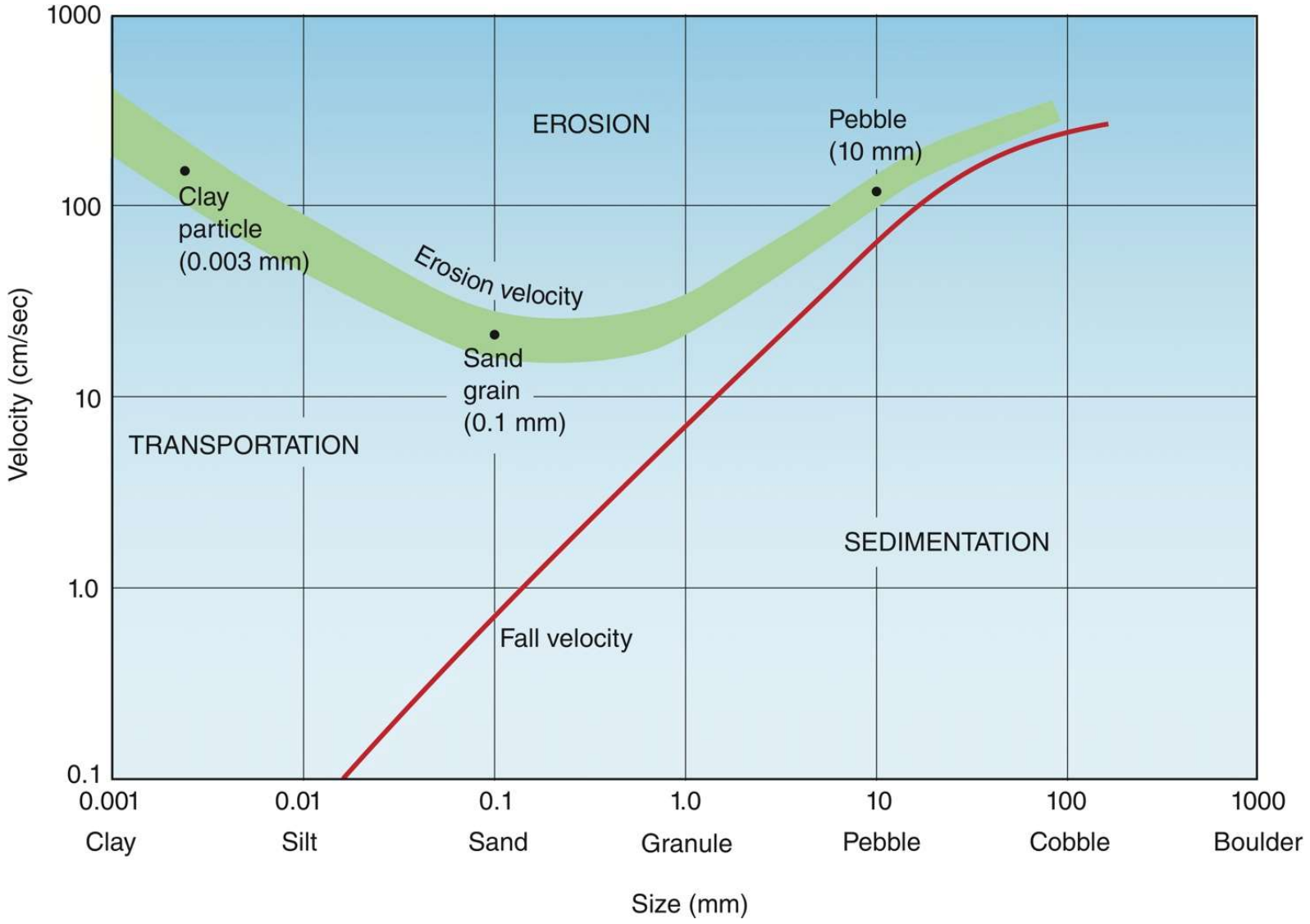
What is the difference between traction and saltation?

Ron Sherman/Getty Images

What are some of the major tributaries that enter the Mississippi River?

Fluvial Processes (cont'd.)

- Stream deposition
  - Decreased flow velocity: load reduced through deposition
  - Bar
    - Sediment accumulation, e.g., formation on the inside of a channel bend
  - Alluvium
    - General term for fluvial deposits



Fluvial Processes (cont'd.)

- Stream deposition
  - When flooding occurs, what is the impact on:
    - Channel cross-sectional width?
    - Flow velocity?
    - Stream competence?
    - Sediment deposition?
  - Floodplains

FEMA/Barry Bahler

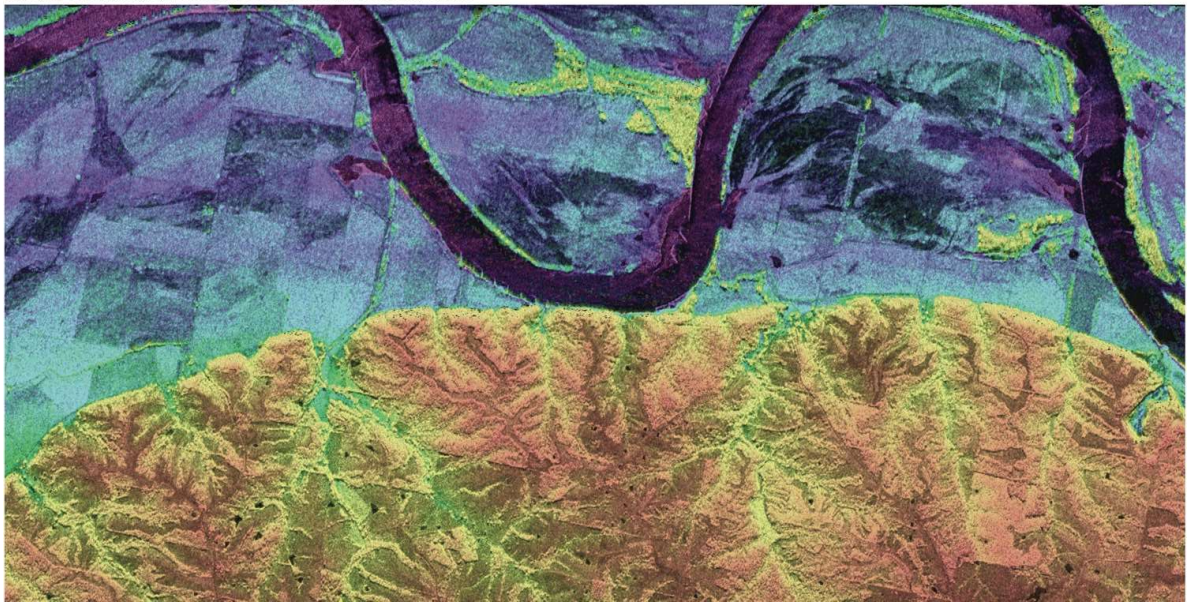
What do think the ground surface looked like immediately after the water receded?

D. Sack

Channel Patterns

- Principal types of stream channel
  - Straight channels
  - Braided channel: what typically causes this pattern to develop?
  - Meandering channels

NASA/JPL TOPSAR; image generation performed at Washington University, St. Louis



Fluvial Landscapes

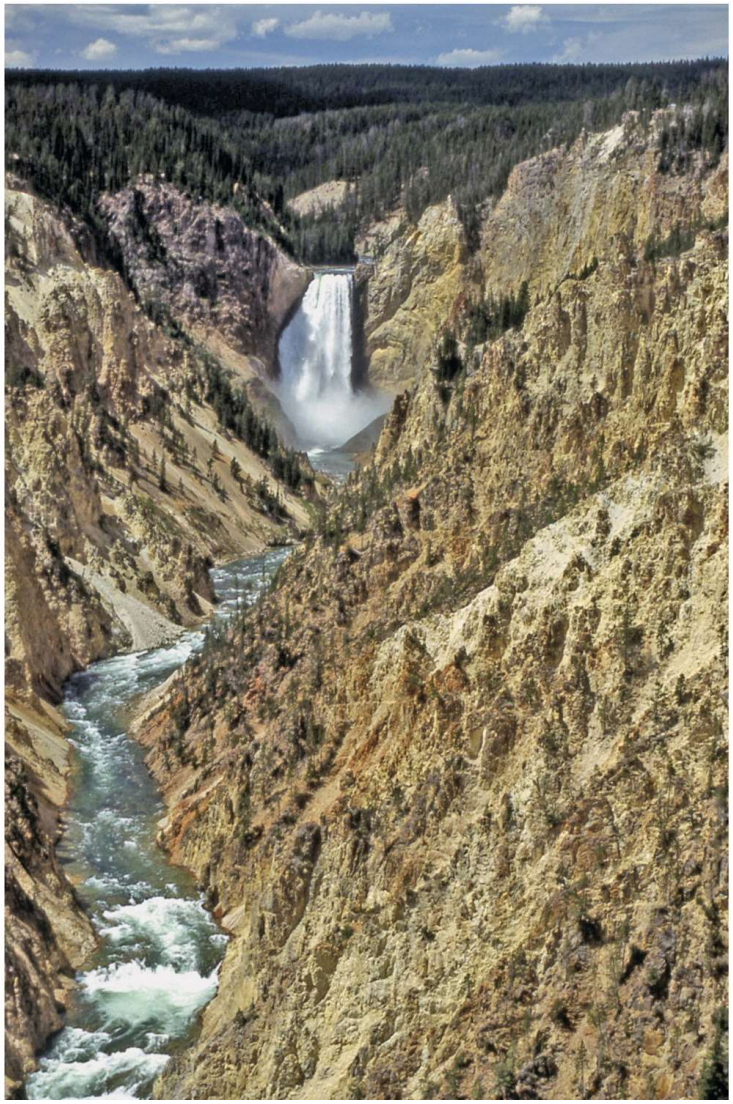
- Idealized river: generalized characteristics
  - Gradient: diminishes continually downstream
  - River sections: upper, middle, and lower
  - Features of the upper course
    - Stream flows in contact with bedrock
    - Steep gradient: erosion by hydraulic action and abrasion
    - Little, if any, floodplain

Fluvial Landscapes (cont'd.)

- Idealized river: generalized characteristics
  - Features of the upper course
    - V-shaped valleys
    - Significant differential erosion
  - Features of the middle course
    - Moderate gradient
    - Moderately smooth channel bed
    - Floodplain present
    - Definite valley walls beyond the floodplain

Jake Rajs/Getty Images

What evidence do you see that indicates lateral changes in the stream's position on its floodplain?

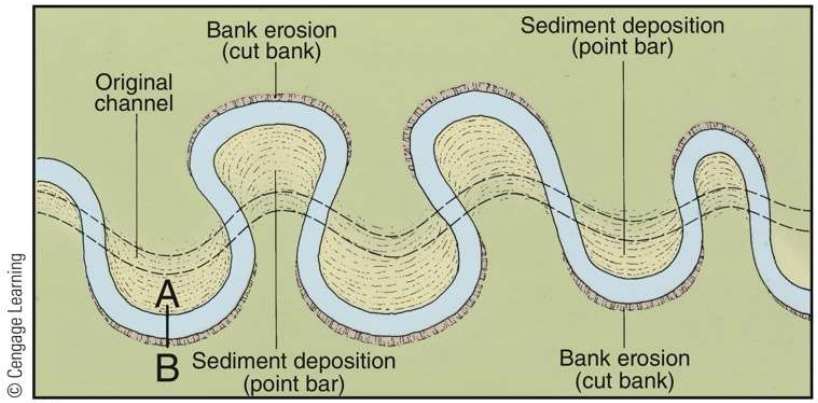


NPS photo by Ed Austin/Herb Jones

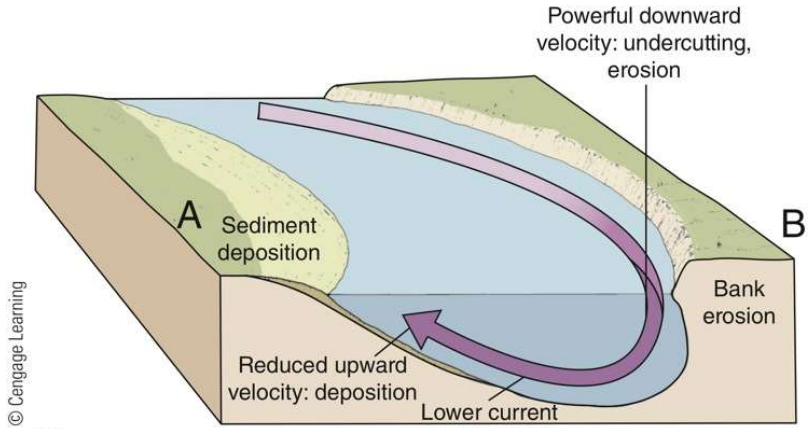
How does the gradient of the Yellowstone River compare with that of the stretch of the Mississippi River shown in Figure 14.20?

Fluvial Landscapes (cont'd.)

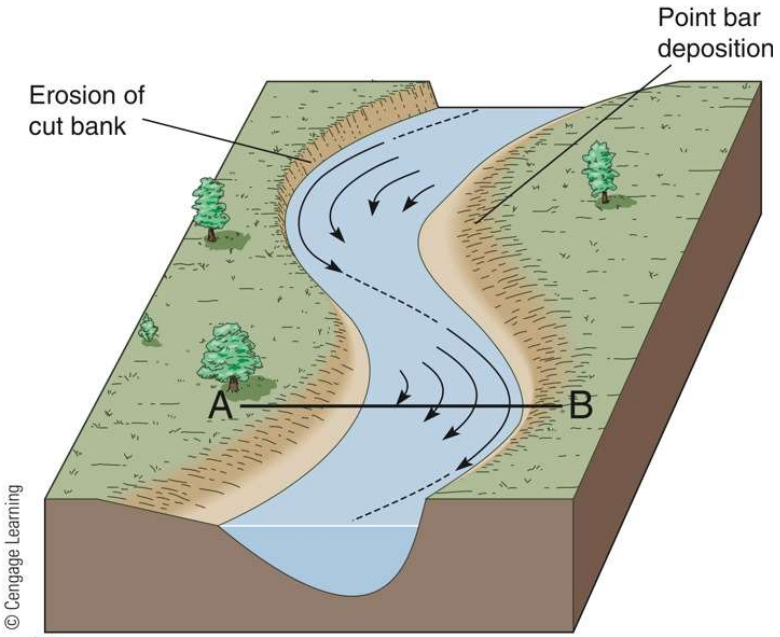
- Idealized river: generalized characteristics
  - Features of the middle course
    - Lateral erosion
    - Meandering channel: featuring cut banks and point bars
  - Features of the lower course
    - Minimal gradient
    - Stream energy: attributed to higher discharge
    - Alluvial plains


Bank erosion
(cut bank)
Sediment deposition
(point bar)
Original
channel
A
B
Sediment deposition
(point bar)
Bank erosion
(cut bank)
© Cengage Learning

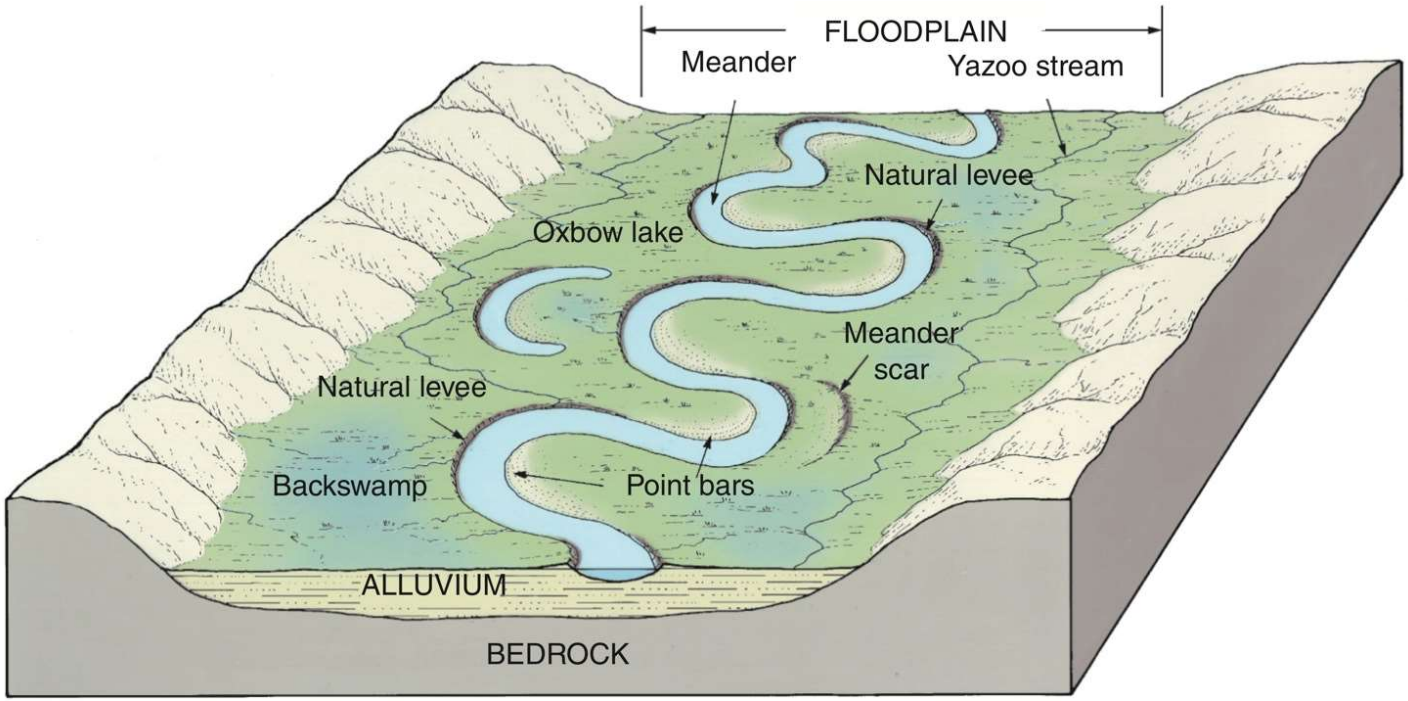
(a)


Powerful downward
velocity: undercutting,
erosion
A
Sediment
deposition
B
Bank
erosion
Reduced upward
velocity: deposition
Lower current
© Cengage Learning

(b)


Point bar
deposition
Erosion of
cut bank
A
B
© Cengage Learning

(c)



What is the origin of an oxbow lake?

Fluvial Landscapes (cont'd.)

- Deltas
  - Develop at river mouths
    - Aggradation
  - Types
    - Bird's-foot delta
    - Arcuate delta
    - Cuspate delta

NASA Earth Observatory image by Jesse Allen and Robert Simmon, using EO-1 ALI data from the NASA EO-1 team.

(a)

NASA JSC

(b)

Fluvial Landscapes (cont'd.)

- Base-level changes and tectonism
  - Elevation changes
    - Tectonic uplift or depression
  - Rejuvenated
  - Entrenched
  - Stream terraces
    - Successive periods of downcutting and deposition

© Rainer Duttmann

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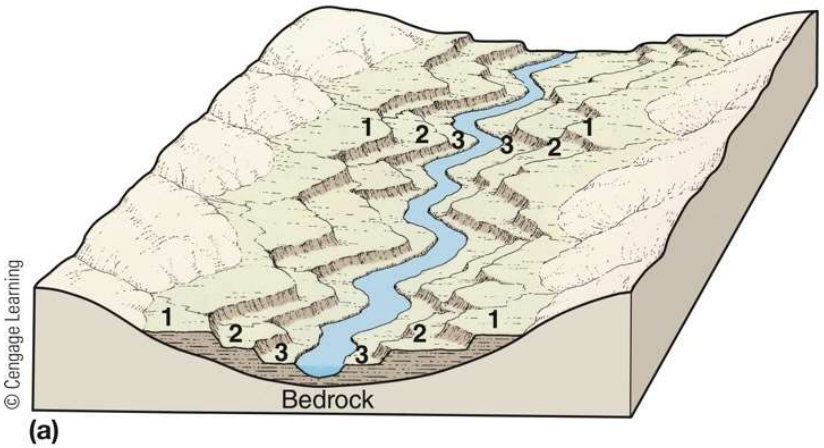
What type of load is this stretch of the river transporting?



(a)

(b)

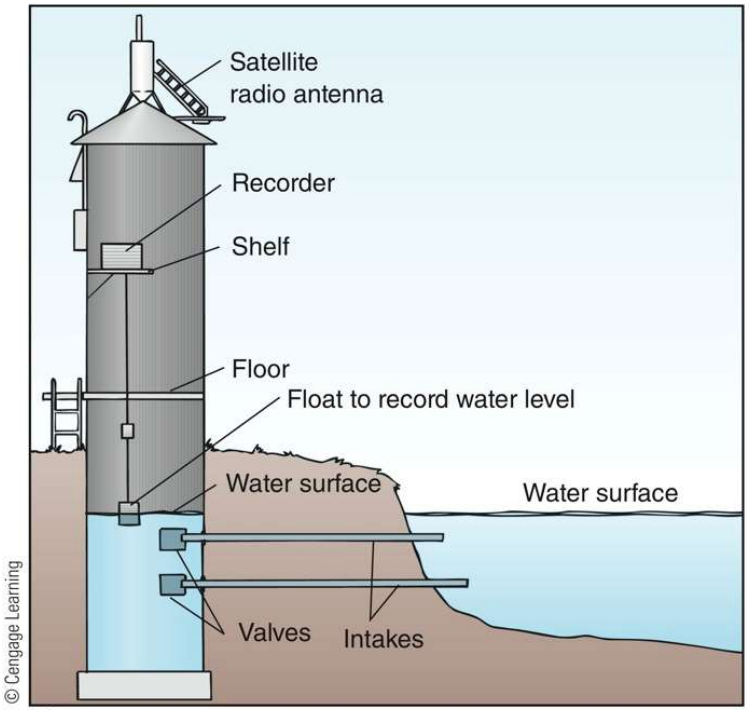
How many terraces can you identify in this photo?

Rivers, Lakes, and People

- Stream hazards
  - Flooding
  - U.S. Geological Survey: gaging stations
  - Stream hydrograph
    - What is the meaning of various characteristics of a climbing, peaking and descending curve?

John Trotter/Sacramento Bee/ZUMA

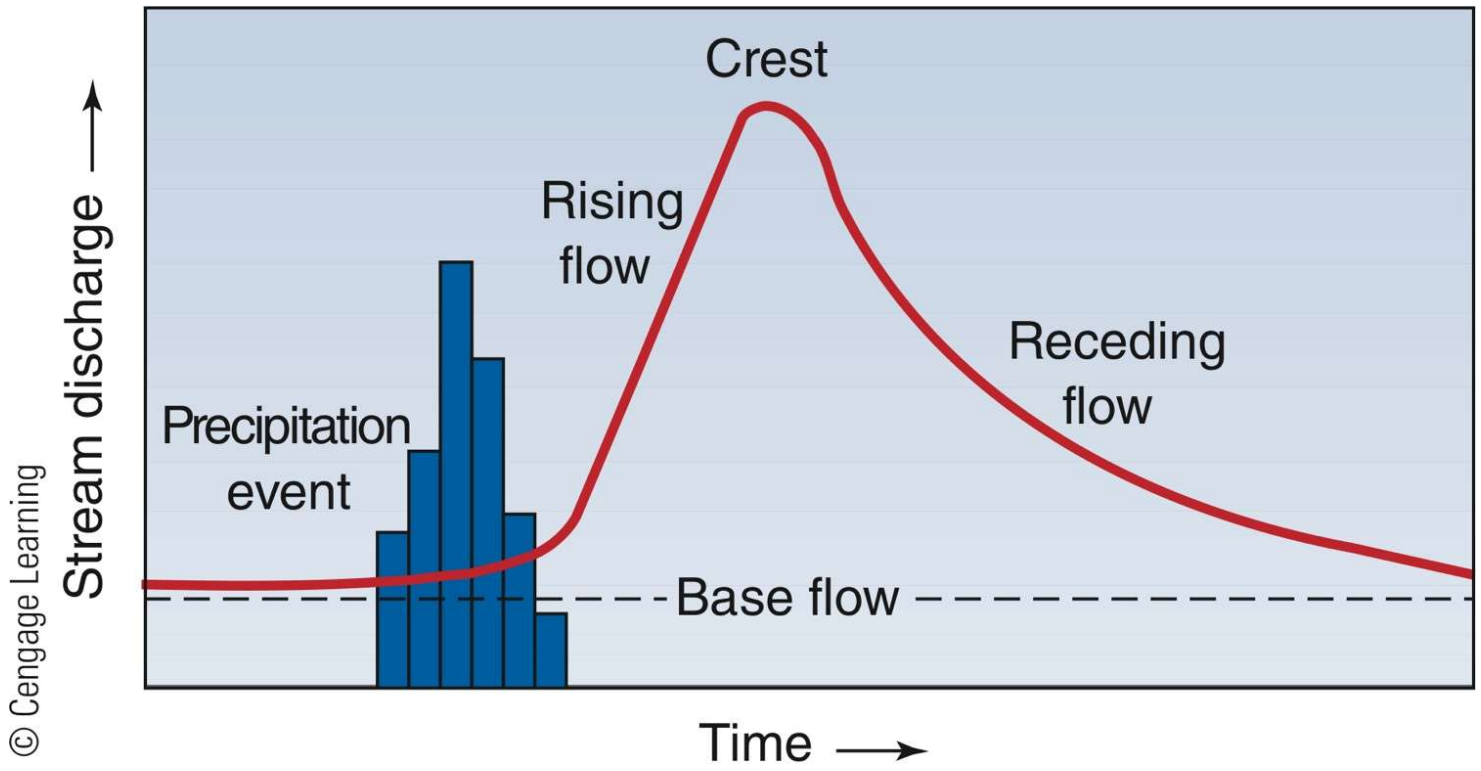
What can be done to prepare for or to avoid flood problems?



(a)

J. Petersen

(b)



Why is there a lag between the time that precipitation started and the rise of the river?

D. Sack

What features of the urbanized landscape shown here enhance runoff?

Rivers, Lakes, and People (cont'd.)

- Importance of rivers
  - Historically: settlement and growth of the U.S.
  - Transportation: bulk cargo, grain, lumber, etc.
  - Generate power
  - Irrigation
  - Food and water
  - Recreation

Rivers, Lakes, and People (cont'd.)

- Importance of lakes
  - Temporary storage of fresh water
  - Fishing and recreation
  - Moderating effect on temperature
    - Increase precipitation (lake effect)
- River systems
  - Reservoirs

U.S. Army Corps of Engineers, Portland District

What are some of the purposes that dams serve?

Quantitative Fluvial Geomorphology

- Benefits of quantitative studies
  - Understand origins and formational processes of landforms and landscapes
  - Predict water supplies and flood hazards
  - Estimate soil erosion
  - Trace sources of pollution

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14

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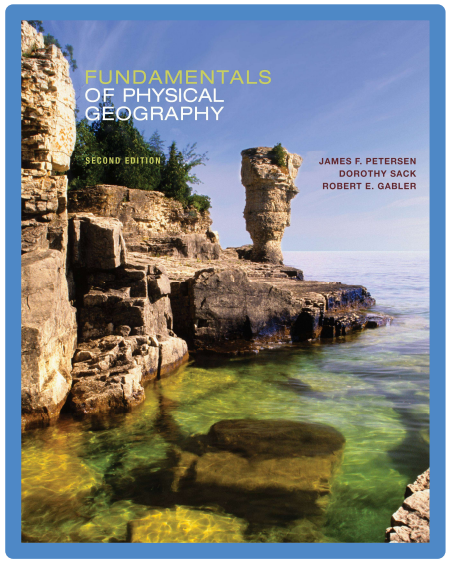

- Peterson
  - Sack
    - Gabler