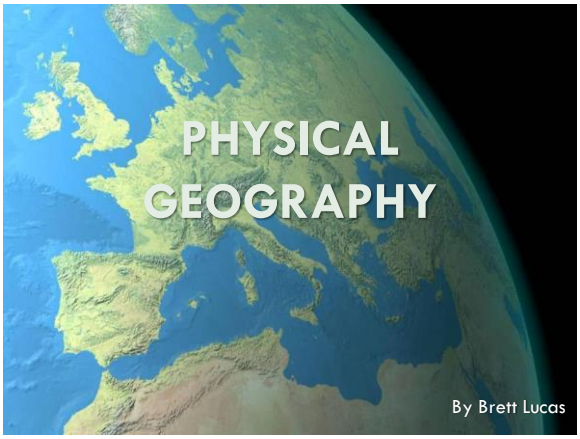


FLUVIAL PROCESSES

Fluvial Processes

- The Impact of Fluvial Processes on the Landscape
- Streams and Stream Systems
- Stream Channels
- Structural Relationships
- The Shaping and Reshaping of Valleys
- Floodplains
- Stream Rejuvenation
- Theories of Landform Development

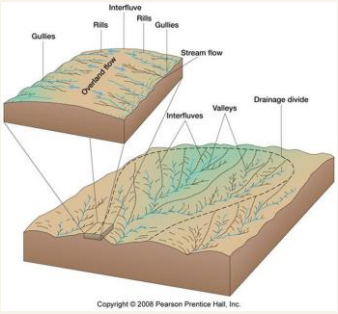
The Impact of Fluvial Processes on the Landscape

- Fluvial processes involve running water
- Running water is Earth's most important external agent
- This process is ubiquitous (everywhere) except in Antarctica

Streams and Stream Systems

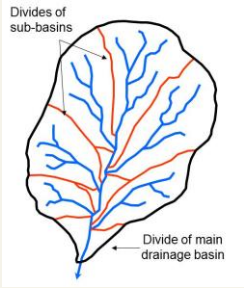
- Streamflow and Overland Flow
  - Streamflow – channeled movement of water along a valley bottom
  - Overland flow – unchanneled downslope movement of surface water
- Valleys and Interfluves
  - Valley – drainage system of channeled (stream) flow
    - Valley bottom and valley walls
  - Interfluve – No clearly established channeled flow
    - High area between valleys ("top of the ridge")
    - Leads to overland flow, see next slide.

Valleys and interfluves



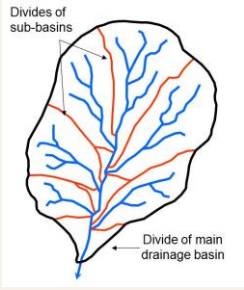
Drainage Basins (Watersheds)

- This is all the area that contributes overland flow and groundwater to a stream.
- The bigger a river is, the larger its drainage system would be.
- In Geography, "rivers" and "streams" are used interchangeably.



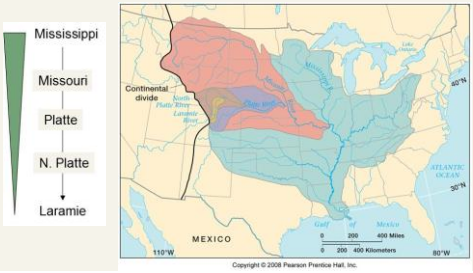
Drainage Basins (Watersheds)

- Drainage basins include the following:
  - Valley bottom
  - Valley sides
  - Interfluves that drain toward the valley
  - Drainage divides
  - Main stream basin (black boundary line in the diagram)
  - Tributary sub-basins (red boundary line in the diagram)



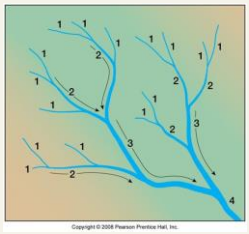
Hierarchy of Drainage Basins

- Larger basins *include* a hierarchy of smaller tributary basins.



Stream Orders

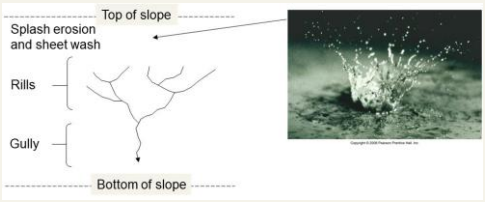
- First-order stream
  - Smallest stream, *has no tributaries*
- Second-order
  - Begins at confluence of 1st order streams
- Third-order
  - Begins at confluence of 2nd order streams



Fluvial Erosion and Deposition

- Erosion by Overland Flow
- It happens in 3 stages:
  - Splash erosion and sheet wash
  - Rill erosion and
  - Gully erosion. Once the gullies are deep enough, they eventually become streamflow

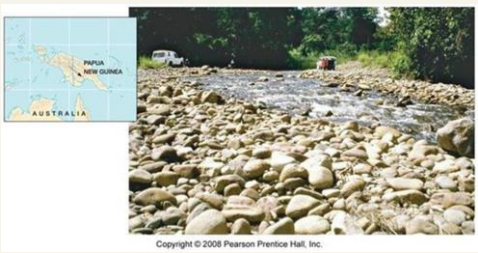
Fluvial Erosion and Deposition



Erosion by Streamflow

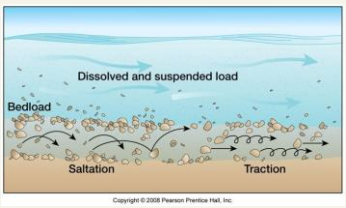
- Causes abrasion of streambed and rounded rock fragments, seen at right Some chemical weathering of channel
- Amount of erosion depends on:
  - Volume of flow
  - Flow speed
  - Turbulence of flow

Erosion by Streamflow



Stream Sediment Movement

- Transportation
  - Load – eroded debris carried by overland flow or streams
  - Types of load: dissolved, suspended and bedload



Stream Sediment Movement

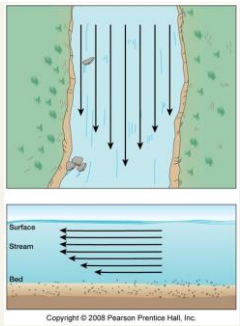
- Deposition
  - Alluvium
    - The general term for stream deposited debris
    - They occur on sorted/stratified deposits, esp. if flooding/deposition happens over a different periods time
    - Usually smooth, rounded particles (discussed before)
  - Cause of alluvium: Decrease in flow speed

The Role of Floods

- Floods – periods of peak stream flow
- They erode upper portions of valleys and form vast floodplains in lower parts of valleys
- Sometimes leads to certain types of streams:
  - Perennial stream (permanent)
  - Intermittent stream (temporary) or Ephemeral (very temporary
- Streams are intermittent if they flow only for part of the year (e.g. rainy season). Usually shown on topographic maps with dotted blue lines, instead of complete blue lines.
- Streams are ephemeral if they flow only during or immediately after heavy rains. E.g. in a desert, where certain flowers can complete their whole life cycle in one day! (ephemeral plants).

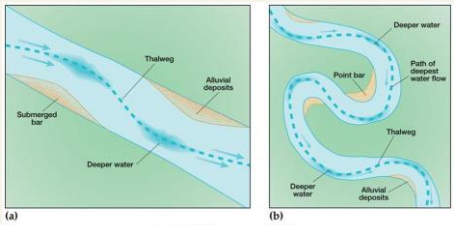
Stream Channels

- Channel Flow
  - Friction causes water to flow slowest along the banks and at the bottom of the stream. It's fastest in the middle and at the surface



Stream Channel Patterns (4 types)

- Straight channels (uncommon)
  - Usually short sections of a channel
  - Eventually take on sinuous characteristics due to scouring and filling



Stream Channel Patterns (4 types)

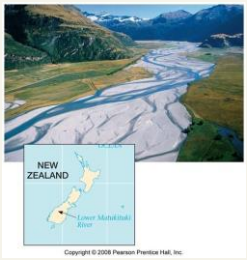
- Sinuous Channels
  - Common
  - Gentle winding channels
  - Found in both steep and gentle gradients
  - But the flatter the land, the more sinuous a stream becomes; eventually, it becomes a meander.

Stream Channel Patterns (4 types)

- Meandering Channels
  - Occurs where land is flat, such as large floodplains
  - Tightly curved loops, very serpentine (see picture of River Missouri).
  - Also forms abandoned channels. E.g. Oxbow lakes, like Carter Lake in Omaha.

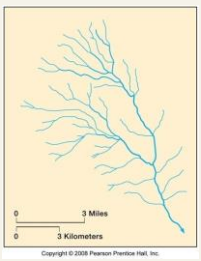
Stream Channel Patterns (4 types)

- Braided Channels
  - Heavily loaded stream
  - Gentle gradient slows flow speed
  - Slow moving stream chokes channel with alluvium
  - Sand and gravel bar deposits divide (braid) the stream



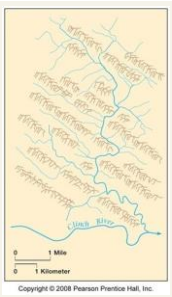
Stream Drainage Patterns

- Dendritic Drainage Pattern
  - Most common drainage pattern
  - Tree-like, angles less than 90 degrees (see figure).
  - But in this case, underlying structure does not control the pattern, since it's found in almost flat land

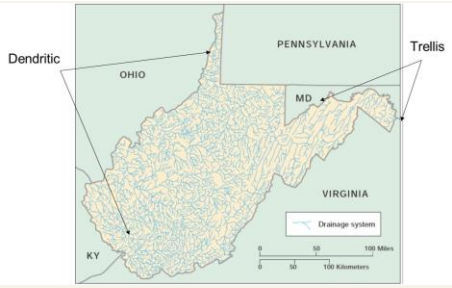


Stream Drainage Patterns

- Trellis Drainage Pattern
  - Caused by alternating bands of tilted hard and soft rocks
  - Long parallel streams cut into soft rocks
  - Parallel streams are jointed by short, right-angled segments.

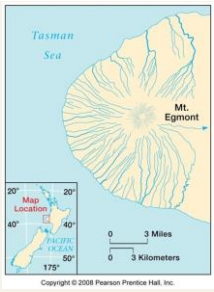


Stream Drainage Patterns



Stream Drainage Patterns

- Radial Drainage Pattern
  - Streams drain from a mountain peak or volcano

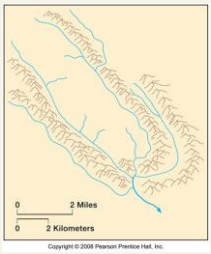


Stream Drainage Patterns

- Centripetal Drainage Pattern
  - Here, streams 'converge' into a basin (opposite of radial pattern, where they 'radiate away')

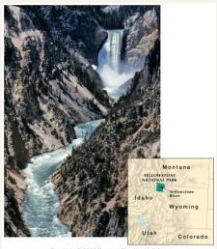
Stream Drainage Patterns

- Annular Drainage Pattern
  - Streams converge into a basin, in right angles between hard and soft rock (almost sounds like the trellis pattern at first, but these branches here all converge at once).

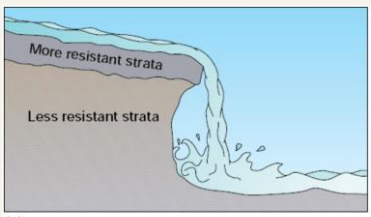


The Shaping and Reshaping of Valleys

- Valley Deepening
  - Downcutting and V-shaped Valleys
  - Usually by streams with rapid speed or large volume
  - Base level is the lower limit of down-cutting that a stream can do.

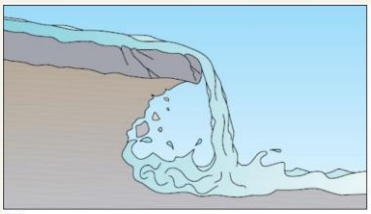


Knickpoint Migration



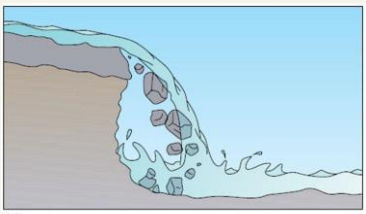
(a)

Knickpoint Migration



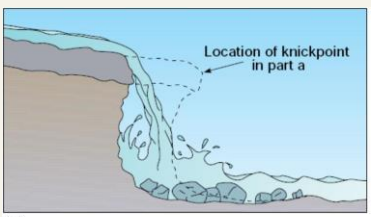
(b)

Knickpoint Migration



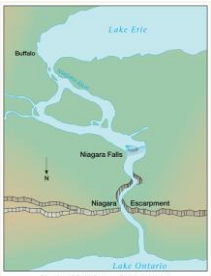
(c)

Knickpoint Migration



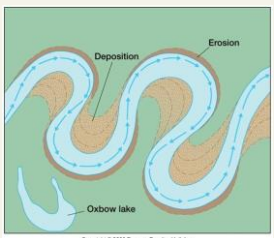
(d)

Niagara Falls (Knickpoint) Retreat

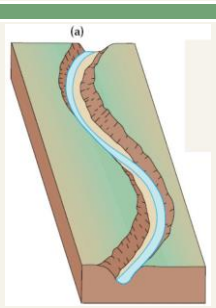


Valley Widening

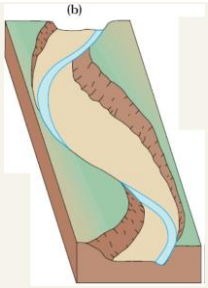
- Lateral (side) erosion by a meandering stream. i.e., side-to-side erosion.
- Water moves *fastest* on the <u>outside</u> of a curve (where it erodes), and *slowest* on the <u>inside</u> (where it deposits alluvium).



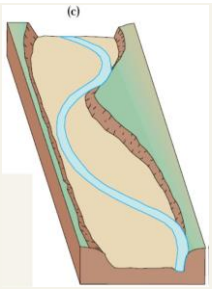
Valley Widening



Valley Widening

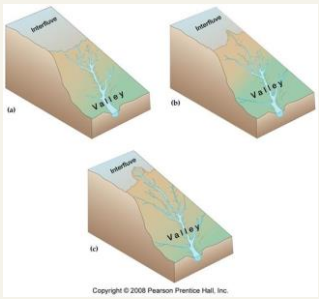


Valley Widening



Valley Lengthening

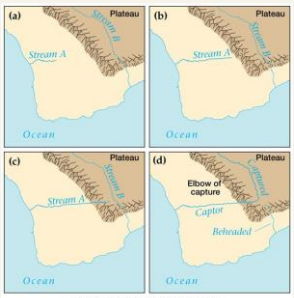
- Headward erosion: when the valley lengthens "backwards" at the expense of the interfluve (land above the valley



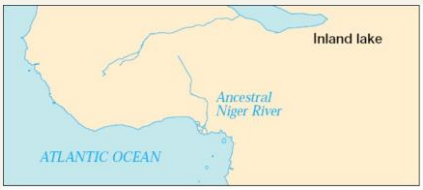
Headward (gully) erosion

Valley Lengthening

- Leading to stream capture or stream piracy

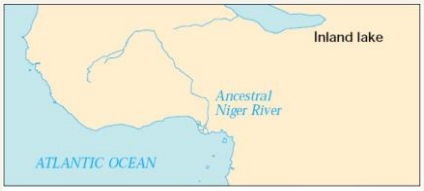


Stream capture



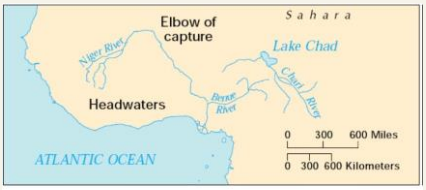
(a)

Stream capture



(b)

Stream capture

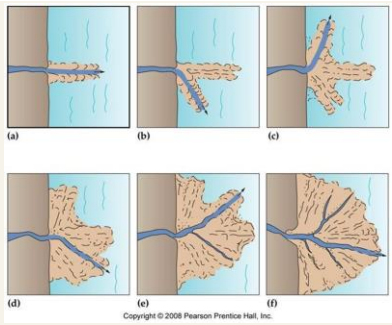


(c)

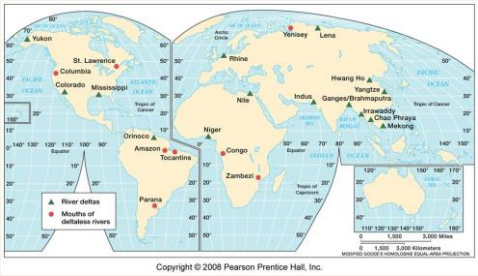
Delta Formation

- River mouth deposits leads to lengthening of stream valley, downstream.
- Some rivers do not have deltas because the ocean currents are so strong that the sediments are just swept away.

Delta Formation



Locations of the world's largest deltas

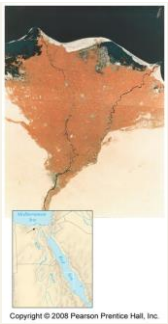


Largest Deltas and Largest Deltaless Rivers

TABLE 16-1 The World's Largest Deltaless Rivers

Rank*	River (Country)
1	Amazon (Brazil)
2	Congo (Democratic Republic of Congo)
6	Yenisey (Russia)
10	Paraná (Argentina)
11	St. Lawrence (Canada)
15	Tocantins (Brazil)
20	Columbia (United States)
21	Zambezi (Mozambique)

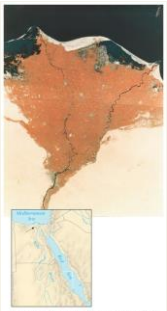
*In terms of average discharge.



Largest Deltas and Largest Deltaless Rivers

TABLE 16-2 The World's Largest Deltas

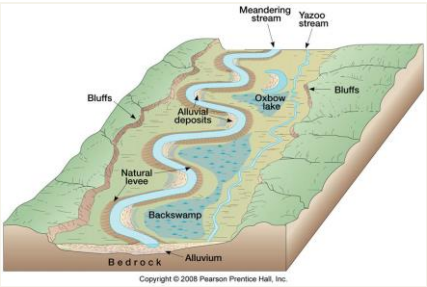
Rank	River (Country)	Area ($km^2 \times 1000$)
1	Indus (Pakistan)	163.0
2	Nile (Egypt)	160.0
3	Hwang Ho (China)	127.0
4	Yangtze (China)	124.0
5	Ganges/Brahmaputra (Bangladesh)	91.0
6	Orinoco (Venezuela)	57.0
7	Yukon (Alaska)	54.0
8	Mekong (Vietnam)	52.0
9	Irrawaddy (Myanmar)	31.0
10	Lena (Russia)	28.5
11	Mississippi (United States)	28.0
12	Chao Phraya (Thailand)	24.6
13	Rhine (Netherlands)	22.0
14	Colorado (Mexico)	19.8
15	Niger (Nigeria)	19.4



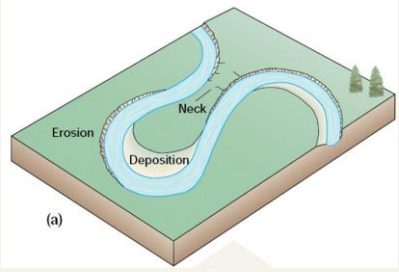
Floodplains

- Floodplain Landforms
  - Floodplain – low-lying, flat alluvial valley floor
  - Very prone to flooding; buildings prohibited by FEMA

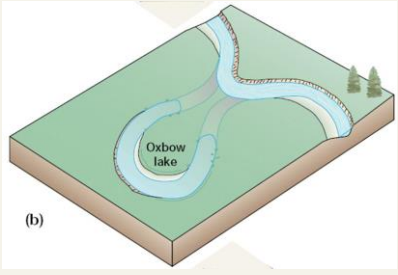
Floodplain Landforms



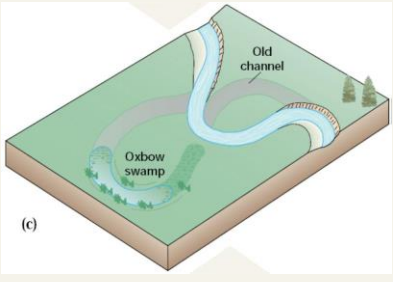
Landform Formation



Landform Formation

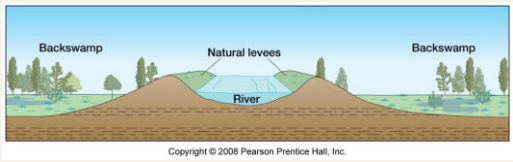


Landform Formation



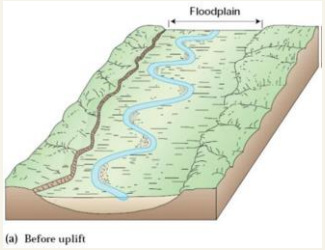
Landform Formation

Natural levee



Stream Rejuvenation

- Tectonic Uplift
  - Increased gradient
  - Dramatic downcutting
- Landforms
  - Stream Terraces
  - Entrenched Meanders



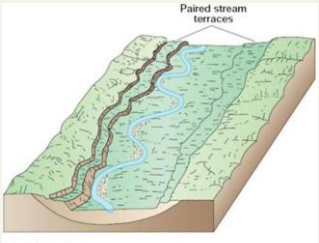
Stream Rejuvenation

- Tectonic Uplift
  - Increased gradient
  - Dramatic downcutting
- Landforms
  - Stream Terraces
  - Entrenched Meanders

(b) Uplift

Stream Rejuvenation

- Tectonic Uplift
  - Increased gradient
  - Dramatic downcutting
- Landforms
  - Stream Terraces
  - Entrenched Meanders

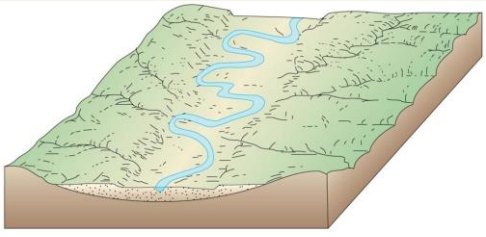


(c) After uplift

Entrenched Meanders

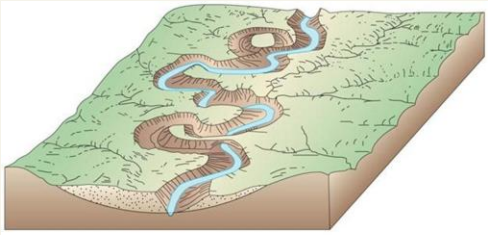
(a)

Meander Entrenchment



(b) Floodplain meanders

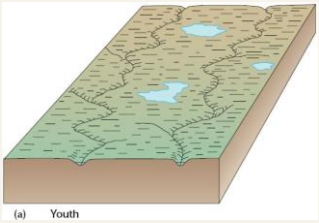
Meander Entrenchment



(c) Entrenched meanders

Theories of Landform Development

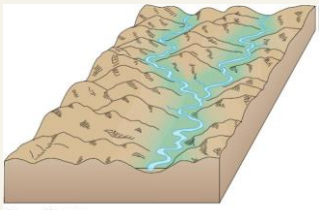
- Davis' Geomorphic Cycle
  - Model
  - Assumptions
  - Stages
  - Youth
  - Maturity
  - Old Age
  - Rejuvenation



(a) Youth

Theories of Landform Development

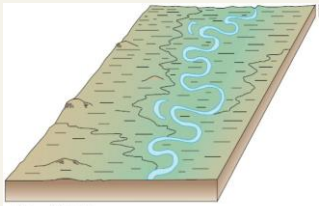
- Davis' Geomorphic Cycle
  - Model
  - Assumptions
  - Stages
  - Youth
  - Maturity
  - Old Age
  - Rejuvenation



(b) Maturity

Theories of Landform Development

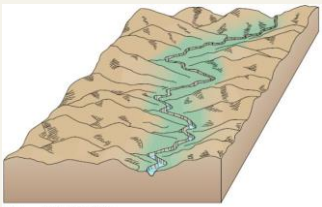
- Davis' Geomorphic Cycle
  - Model
  - Assumptions
  - Stages
  - Youth
  - Maturity
  - Old Age
  - Rejuvenation



(c) Old age

Theories of Landform Development

- Davis' Geomorphic Cycle
  - Model
  - Assumptions
  - Stages
  - Youth
  - Maturity
  - Old Age
  - Rejuvenation



(d) Rejuvenation