Where do paleontologists find dinosaur fossils?

- Dinosaur fossils are found in sedimentary rocks
  - Sedimentary rocks preserve information vital to understanding dinosaurs
  - Environment of deposition
    - Physical habitat where dinosaur lived
    - Ecological habitat - plants / other animals
  - Taphonomic ("death") circumstances
    - Circumstances of demise
    - How did the fossil become preserved?
### Depositional Environments

Environments where dinosaurs lived:
- Upland Forest
- Floodplain
- Desert
- Coastline

Environments where dinosaurs did not live:
- Reef
- Shelf
- Deep Ocean

### Dinosaur fossils

- Dinosaur fossils commonly found
  - Floodplain
  - Coastline
  - Desert

- Dinosaur fossils usually rare
  - Upland Forest
  - Shelf
  - Reef
  - Deep Ocean

- Dinosaur fossils absent
  - Deep Ocean
We know a lot about dinosaurs that lived in active depositional environments.

Preserving fossils requires two things:
A: Lots of sediments
B: Some place to deposit them (a depression)

Most places on Earth at any given time are NOT sites of sediment deposition, rather, they are sites of erosion. No fossils preserved!

Most sediment ends up being carried by rivers and deposited offshore on the continental shelf. Few dinosaurs preserved!

Tectonics - movement of the Earth’s crust

Trapping sediments in continental environments requires active subsidence (downward movement) of the crust.

Subsidence is usually related to major tectonic events that disturb the crust.
A: Orogeny (mountain building) related to plate collisions.
B: Rifting (plate separation)
Ocean-Continent Convergence

Andes Mountains and Amazon Basin

Nevadan Orogeny
Late Jurassic
West Coast Mountain-Building Episodes (Orogenies) During the Mesozoic Era.

Morrison Formation, Vernal, Utah

Dinosaur National Monument, Vernal, Utah

River channel sand bar environment
Morrison Formation
Morrison, Colorado

river channel
floodplain

Dinosaur trackways
Morrison, Colorado

Dinosaur bone
Morrison, Colorado
Dinosaur bone
Morrison, Colorado

Sevier Orogeny
Cretaceous

Alluvial plain
(Dakota Sandstone)

Subducting Seafloor

Uplifted Mountains

Interior (epicontinental) seaway
Trace Fossils

The Dakota sandstones contain many tracks, trails, and burrows of worms and crustaceans that lived in the intertidal zone along the western seashore of the Western Interior Seaway. Although these animals were never preserved in the sand, the “traces” they left behind give us clues as to what kind of animals they were. The horizontal and vertical burrows are similar to those known from modern sandy beaches.

Mangrove Swamp

The impressions of tree limbs and roots in the Dakota sandstones are probably trace fossils of a 100 million year old mangrove swamp that formed next to the shore of the Western Interior Seaway. The limbs and roots were covered by sediments and then decomposed, leaving only their impressions preserved in the rocks today.

Wave ripples

Sign sponsored by Karin Bode in memory of her sons Peter & Tony.

Sign sponsored by the Arthur Goldman family.
Wave ripples and trace fossils

Mangrove root traces

Iguanodont trackways
Dakota Sandstone
Early Cretaceous
Mesozoic Rock Formations in the NY Region

Mesozoic rock formations in the

- Early Jurassic
- Late Triassic
- Late Cretaceous
Breakup of Pangea - Late Triassic Onward

Source: Dietmar Muller - Sydney University.
Mesozoic rift basins in North America

Source: http://geology.rutgers.edu/103web/Newarkbasin/NB_geology.html

Half-graben rift basin


Geologic map of the Newark Basin

Source: http://geology.rutgers.edu/103web/Newarkbasin/NB_geology.html
Modified from Schlische (1992) and Olsen et al. (1996).
Geologic cross section of the Newark Basin

Sedimentary deposition in a growing rift basin

Lake and shoreline
beige siltstone
and dark shale

Braided river / floodplain
red sandstone and siltstone

Alluvial fan
conglomerate
and arkose

Bounding fault
Stockton Formation alluvial fan conglomerates

Sedimentary deposition in a growing rift basin

Braided river / floodplain
red sandstone and siltstone

East

Bounding fault

West

Stockton Formation - conglomerate and arkose
River channel and floodplain deposits, New Haven Arkose

Ancient soil horizon (caliche) in New Haven Arkose

Sedimentary deposition in a growing rift basin

Lake and shoreline
beige siltstone
and dark shale

Bounding fault
Dinosaur footprint and ripple marks in sandstone (DSP, Hartford basin)

Lockatong Formation - shale and siltstone deposited in a rift lake

*Semionotus* - Triassic freshwater fish
Late Cretaceous paleogeography

Middle - Late Cretaceous Zuni Sea

Atlantic shoreline far inland of present position

Geologic map of the Atlantic Coastal Plain

Upper Cretaceous Navesink Formation, Big Brook, NJ
Common Navesink Formation Fossils

- **Oysters**
  - Pycnodonte mutabilis
  - Exogyra costata
  - Agerostrea mesenterica

- **Brachiopod**
  - Choristothyris plicata

- **Cephalopod**
  - Belemnitella americana

**Upper Cretaceous dinosaurs of NJ**

- Nodosaurid ankylosaur
  - *Dryptosaurus* (Tyrannosaur?)
- Ornithomimosaur
  - *Coelosaurus*
- Hadrosaurs
  - *Hadrosaurus spp.*

**Sediment Key**
- Gravel
- Sand
- Silt - Mud
- Glauconite

**Figure 1.** Upper Cretaceous Stratigraphy of the New Jersey Coastal Plain

**Taphonomy and Depositional Environments**
Oviraptor skull and egg

Protoceratops adult and juvenile

Lizard
Fossil Mammals

Zambdelestes

Deltatheridium

"Fighting Dinosaurs"

Velociraptor

Protoceratops
Ukhaa Tolgod Facies

E1: cross-bedded sands with dinosaur footprints, but no skeletons.

E2: massive sands with inclined caliche nodules, no skeletons.

F: massive sands, structureless, with perfectly preserved vertebrate skeletons.

Interpretation: deposition by actively migrating sand dunes.
Dinosaur footprint in beds of E1 facies.

Interpretation: dune failure and slumping, massive sand flows.

Interpretation: stabilized dune deposits trampled by dinosaurs.

Sand Hills, Nebraska

vegetated sand dunes
Dinosaur footprint at Ukhaa Tolgad

Bison footprint in Sand Hills dune

Large scale slumping on the slope of a dune, northern Mexico
Sand Hills, Nebraska

Excessive rainfall can cause dune front to fail and sand to flow rapidly downslope, burying landscape beneath structureless alluvial fan deposits.

Animals preserved at Ukhaa Tolgod were buried alive in massive, fluidized sand avalanches.