BERLIN-ICHTHYSOSAUR STATE PARK
HUMBOLDT-TOIYABE NATIONAL FOREST, NEVADA

Giant Ocean Reptiles Frozen in Stone

See, Learn, and Explore

Discover giant reptiles in the ancient oceans of Nevada, dinosaur fossils, a ghost town, and more!
BERLIN-ICHTHYOSAUR STATE PARK, HUMBOLDT-TOIYABE NATIONAL FOREST

The Berlin-Ichthyosaur State Park on the Humboldt-Toiyabe National Forest in Nevada holds secrets of an ancient ocean, where massive marine reptiles called ichthyosaurs swam and hunted sea creatures now long extinct. The site also holds stories of a ghost town, Berlin, where prospectors mined for precious metals in the early days of Nevada.

Much has changed over the history of the Earth as the ocean advanced and receded over what is now Nevada, and volcanic activity created mineral and precious metals deposits that have been mined over the last century. As you read this activity book and work the puzzles, let your imagination wander through the ages of our Earth’s history to a time when giant reptiles swam in the oceans and the earliest dinosaurs began to dominate the land.

MEET THE ICHTHYOSAUR – THE TRIASSIC TERROR!

A giant marine reptile that lived 200 million years ago

HUGE JAWS AND TEETH!

60 FEET LONG!

EYES BIGGER THAN BASKETBALLS!
**Fascinating Ichthyosaur Facts**

**Ichthyosaurs were big!** The biggest fossil ichthyosaurs at the Berlin-Ichthyosaur site are about 60 feet long. Take a look at a school bus (45 feet long) and add another 15 feet. That's how big these marine reptiles were. Their heads were nearly 10 feet long and their tails were more than 25 feet long. They were truly monsters of the deep and fearsome predators of the Triassic seas. They also weighed a lot! Paleontologists estimate that a 60-foot ichthyosaur weighed as much as 40 tons. That’s heavier than three elephants and as heavy as many living whales!

![Ichthyosaur illustration](image)

Ichthyosaurs could grow up to 60 feet, 15 feet longer than a school bus!

**Ichthyosaur, what big eyes you have!** The eye sockets of ichthyosaurs found at the Berlin-Ichthyosaur site are up to 12 inches across; bigger than a dinner plate. Ichthyosaurs had among the largest eyes in relation to their body size of any animal that has ever lived! Big eyes likely helped ichthyosaurs hunt for prey in dark conditions, in deep water where little sunlight penetrates.

![Ichthyosaur skull illustration](image)

Ichthyosaur skulls can be 10 feet long, with an eye socket 12 inches wide!

**Ichthyosaurs were ocean reptiles!** They may have looked similar to dolphins and whales, but ichthyosaurs are reptiles and are more closely related to living alligators and crocodiles. They were air-breathing, ocean-dwelling reptiles, like sea turtles and salt-water crocodiles of today. But paleontologists believe that ichthyosaurs lived similar lifestyles to that of dolphins and porpoises, based on the similarities of body structure and habitat shared by these reptile and mammal groups.

**Ichthyosaurs were everywhere!** Well, almost. Paleontologists have found ichthyosaur fossils on every continent except Antarctica. Ichthyosaurs swam through all the world’s oceans during the Mesozoic Era.

![Ichthyosaur world map](image)

**Ichthyosaur, your name is Greek to me!** In Greek, “ichthys” means fish and “sauros” means lizard, so the scientific name “ichthyosaur” is Greek for “fish-lizard.” The name is fitting, because ichthyosaurs were really big, ocean-living reptiles with a very fishy look!

Say “ichthyosaur” like this: **ICK-thee-o-sore**

To learn about ichthyosaurs, we must understand how the landscape of Nevada has changed through time. Imagine the age of the Earth (4.5 billion or 4,500,000,000 years) as if its entire history takes place during a 5-hour plane ride from New York City to San Francisco. The Earth begins to form as you take off from New York, and the present day is when you land in California. Each minute of the flight represents 15 million years (15,000,000 years)!

The shaded portions of the figure below show the ages of the Earth’s geologic eras. The small airplane icons represent major events in the evolution of life. This Berlin-Ichthyosaur activity book is mainly about life in the Mesozoic Era, represented by about the last 15 minutes before landing in San Francisco. The other 4 hours and 45 minutes of the flight from New York City represent all the time on Earth before the Mesozoic Era. Humans did not appear on Earth until 12 seconds before your plane lands in San Francisco.
The last 40 minutes of your 5-hour flight represent the Phanerozoic Eon. Geologists divide the Phanerozoic Eon into three eras, and then further subdivide the eras into periods, as shown in the table below. We know more about the Phanerozoic Eon than any other time in Earth’s history. Why? Geologists learn about the history of the Earth by studying fossils preserved in rock layers, and rocks at the beginning of the Phanerozoic Eon preserve the first ancient life forms (as fossils) that had hard body parts (shells). Geologists know that limestone is deposited in water, sand collects on a beach or desert, coal forms in swamps, and volcanoes eject ash and lava. Younger sediment layers settle on top of older layers, and if these sediments remain undisturbed, they eventually become deeply buried and are compacted and cemented into rock layers (lithification). By understanding the order of rock layers, and studying fossils contained in the rock layers, geologists have re-created the history of the Earth. The table below summarizes the natural history of the area we now know as Nevada.

<table>
<thead>
<tr>
<th>ERA</th>
<th>PERIOD/EPHOC</th>
<th>SYMBOL</th>
<th>APPROXIMATE AGE*</th>
<th>GEOLOGIC EVENTS IN NEVADA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cenozoic (New Life):</td>
<td>Holocene</td>
<td></td>
<td>Present to 10,000 Y.A.</td>
<td>The “recent” coming of humans in North America</td>
</tr>
<tr>
<td></td>
<td>Pleistocene</td>
<td></td>
<td>10,000 Y.A. to 2 M.Y.A.</td>
<td>The Ice Age, glaciation in Nevada’s mountain ranges</td>
</tr>
<tr>
<td></td>
<td>Pliocene</td>
<td></td>
<td>2 to 6 M.Y.A.</td>
<td>Basin and range extension (pulling apart the Earth’s crust) continues with earthquakes and volcanic eruptions</td>
</tr>
<tr>
<td></td>
<td>Miocene</td>
<td></td>
<td>6 to 22.5 M.Y.A.</td>
<td>Basin and range topography is formed by extension of the Earth’s crust, which is literally pulled apart to form isolated mountain ranges separated by basins, gypsum is deposited in basins</td>
</tr>
<tr>
<td></td>
<td>Oligocene</td>
<td></td>
<td>22.5 to 36 M.Y.A.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eocene</td>
<td></td>
<td>36 to 58 M.Y.A.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paleocene</td>
<td></td>
<td>58 to 65 M.Y.A.</td>
<td>Thrust faulting from the west created the ancient Sevier Mountains, with deposition of ore deposits</td>
</tr>
<tr>
<td>Mesozoic (Middle Life):</td>
<td>Cretaceous</td>
<td>K</td>
<td>65 to 141 M.Y.A.</td>
<td>Igneous activity resulting in deposition of ore</td>
</tr>
<tr>
<td></td>
<td>Jurassic</td>
<td>J</td>
<td>141 to 195 M.Y.A.</td>
<td>The ancient Sonoma Mountain range arose in the central part of the state with volcanoes in the west</td>
</tr>
<tr>
<td></td>
<td>Triassic</td>
<td>T</td>
<td>195 to 230 M.Y.A.</td>
<td></td>
</tr>
<tr>
<td>Paleozoic (Ancient Life):</td>
<td>Permian</td>
<td>P</td>
<td>230 to 280 M.Y.A.</td>
<td>Volcanic eruptions to the west and marine deposition to the east</td>
</tr>
<tr>
<td></td>
<td>Pennsylvanian</td>
<td>P</td>
<td>280 to 310 M.Y.A.</td>
<td>Erosion of the Antler Mountains</td>
</tr>
<tr>
<td></td>
<td>Mississippian</td>
<td>M</td>
<td>310 to 345 M.Y.A.</td>
<td>Thrust faults (rocks broken and pushed over each other) in the west created the ancient Antler Mountain range, with deposition of sedimentary rock in the east</td>
</tr>
<tr>
<td></td>
<td>Devonian</td>
<td>D</td>
<td>345 to 395 M.Y.A.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Silurian</td>
<td>S</td>
<td>395 to 435 M.Y.A.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ordovician</td>
<td>O</td>
<td>435 to 500 M.Y.A.</td>
<td>Deep water marine deposition of limestone in the east and shallow marine deposition of sandstone and shale in the west</td>
</tr>
<tr>
<td></td>
<td>Cambrian</td>
<td>C</td>
<td>500 to 600 M.Y.A.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Precambrian</td>
<td>pC</td>
<td>Older than 600 M.Y.A.</td>
<td>Formation of the Earth, oceans, land, and life over a period of 4 billion years</td>
</tr>
</tbody>
</table>

*Y.A. = years ago; M.Y.A. = millions of years ago
Wonderful, Mysterious Landforms of Nevada

Nevada’s geology is unique and is very different from the other 49 States. Why? Nevada is almost completely within a region called the Great Basin, where rivers flow in but they don’t flow out. Nevada is also located within the “rain shadow” of the Sierra Nevada Mountains to the west, resulting in dry, desert conditions across the State. Nevada has more than 300 mountain ranges that align in a north-to-south direction and are separated by valleys. In fact, Nevada has the most mountain ranges of all the lower 48 States!

Streams flow out of the mountains and disappear into the valleys. Seasonal lakes located in the valleys (called playas) fill with water when it rains and then dry up. Bedrock exposed in the mountains is broken by faults. “Faults” are large cracks where rock formations can shift and move. Volcanic rocks form a thin blanket over all the other geology.

The incredible geologic forces that created this unique landscape are called plate tectonics. Huge plates that make up the Earth’s crust slowly move over molten rock deep within the Earth. These plates can shift where they share a boundary with other plates. Shifting plates can create volcanoes, mountains, valleys, or basins. We can understand how the mysterious landforms of Nevada were created by exploring these mountains and valleys.

Broken and Faulted Bedrock: Nevada has undergone three major periods of mountain building, called “orogenies:”

- the Antler Orogeny, about 340 million years ago.
- the Sonoma Orogeny, about 250 million years ago.
- the Sevier Orogeny, about 100 million years ago.

These episodes of mountain building resulted from massive plates of Earth’s crust colliding along North America’s west coast (plate tectonics), which caused faulting and folding of rock layers far inland, and shoved rock layers eastward along massive broken rock surfaces called thrust faults.

Two types of faulting created these mountains, as shown in the illustrations below. Rotational fault blocks (left) result when the crust breaks in a stair-step fashion along a series of faults. The crustal blocks slip and rotate to form mountain ranges with valleys in between. Horst and graben mountain building (right) results when blocks of the crust either drop down (grabens) or are pushed up (horsts) along the faults. The result of both mountain-building processes is similar, producing linear mountain ranges separated by valleys (basins).

Basin and Range Topography: One look at a satellite image of Nevada shows a highly wrinkled land surface! These wrinkles are individual mountain ranges separated by valleys in a large area that geologists call the Basin and Range Province. These mountain ranges formed by pulling apart the Earth’s crust, rather than forming by crustal blocks pushing together. The crustal block that makes up California began pulling away around 30 million years ago, causing the Earth’s crust in Nevada to stretch and pull apart. The brittle crust cracked (faulted), and some blocks of crust remained in place while others dropped. Blocks of crust that remain elevated form the mountain ranges, while blocks that are lower form basins.

![Basin and Range Topography Diagram](image-url)
The geologic unrest that produced Nevada’s varied geologic history continues to this day: Nevada ranks third in the country in earthquake activity, behind California and Alaska.

**ALL THOSE VOLCANOES:** Nevada has had a lot of volcanic activity! Why? Both compression and extension of the Earth’s crust can create volcanoes. Extension of the continental crust around 14 million years ago produced the most recent volcanoes of Nevada. Magma (molten rock) below the crust shot up through cracks that formed as the continental crust stretched thin. This formed explosive volcanoes that ejected massive flows of molten rock and ash, called pyroclastic flows by geologists. The pyroclastic flows moved at incredible speeds, estimated at more than 100 miles an hour, and buried everything in their path. Remnants of this volcanic activity are found across Nevada, capping bedrock exposures of mountain ranges.

**GREAT BASIN DRAINAGE:** Rivers flow into a unique landform in northern Nevada called “The Great Basin” (see map below). These rivers don’t flow out because the basin has no drainage outlets to the Pacific Ocean, the Gulf of California, or the Gulf of Mexico. Where does the water go? It flows into lakes. The lake water may quickly evaporate or seep into the ground in lakes called sinks. Longer lived lakes may form in the dry valleys between the mountain ranges during times when there is a lot of precipitation (rain or snow). These “playa lakes” are not permanent; they only form during times of high precipitation and then disappear through evaporation when the weather is dry.

**DRY NEVADA IN THE RAIN SHADOW OF THE SIERRA NEVADA MOUNTAINS:** Present-day Nevada does not have much precipitation, and much of Nevada can be called a desert! Why? Winds that cause weather changes in the southwestern United States tend to come from the west and move east. Air moving east from the Pacific Ocean toward Nevada is moist and relatively warm. The air cools as it flows up over the west side of the Sierra Nevada Mountains. Atmospheric pressure also weakens as the air moves higher on the mountain slopes. This combination of lower pressure and cooler temperatures causes the moist air to form clouds that drop rain or snow along the west side of the Sierra Nevada Mountains. Most of the moisture in the air is gone by the time the clouds cross the mountains, leaving the east side of the mountains and the State of Nevada with little precipitation. This is called a rain shadow effect, as shown in the illustration below. Rain shadow effects developed in Nevada about 6 million years ago as the Sierra Nevada Mountains rose up.
**Activity: “Plate-dough Tectonics”**

Use modeling clay or dough to make your own basin and range landscape and see plate tectonics in action. Make a rectangular block and use a dinner knife to make cuts through the clay like the drawings below. The diagonal cuts (left drawing) create rotational fault blocks, and the V-shaped cuts (right drawing) create horst and graben fault blocks. Gently pull the ends of each clay roll apart to cause extension or push them together to cause compression. The clay blocks shift and rotate to form a basin and range landscape.

You can also make mountain ranges by compressing tectonic blocks. Start with two long, flat rectangular blocks (first drawing below). Push the small ends of the blocks together, as shown in the second drawing. One block will fold up and over the other block, creating a small mountain range. The buried block shows a process geologists call subduction. Typically along continental margins such as California’s coast, the subducted (buried) block is oceanic crust. Oceanic crust is cooler and formed of denser rock, and gets pushed below (subducted) the warmer, less dense continental crust. As the subducted block gets deeper, increased heat and pressure cause it to melt, creating volcanoes when magma erupts through the block above.

You can also use food to demonstrate plate tectonics. Layer a soft food, such as frosting or peanut butter, on a plate. This represents the Earth’s mantle. On top of your mantle, place two cookies or crackers, which represent the Earth’s crust. Move the two crust pieces over the mantle. See how different movements cause the mantle to ooze up or the plates to crack. You can make transform (move side to side), divergent (move apart), and convergent (move together) plate boundaries. What type of plate boundary causes subduction?

This map shows what Nevada would have looked like during the Triassic Period. Much of the area was covered in a shallow sea. The western area had volcanoes created by folding and faulting in the Earth’s crust.
The Nevada landscape looks very different today than it did during the Triassic Period when ichthyosaurs roamed the oceans. Try to imagine the present-day mountainous basin and range landscape of the Berlin-Ichthyosaur site as an ocean! How do we know what the Triassic environment was like 200 million years ago? Geologists interpret rocks and fossils using the scientific principle called uniformitarianism, which means “the present is the key to the past.” This means that the geologic events we observe today also occurred in the distant past and shaped ancient landscapes in similar ways to events that shape the landscape today. Volcanoes, floods, winds, oceans, and rivers have affected the Earth throughout time, depositing or eroding recognizable layers of sediment and rock in the past, just as they do now.

Fossils also provide clues about ancient environments. Geologists compare fossils from various bedrock formations to understand how ancient communities of organisms were spread among the diverse paleoenvironments of Nevada’s Triassic landscape. Ammonite and tiny conodont fossils tell us as much about Nevada’s ancient oceans as the giant ichthyosaur bones.

Why have the Earth’s surface environments continued to change dramatically throughout geologic time? Plate tectonics is the driving force behind much of this change. The movement of these plates has raised mountain ranges and volcanoes, produced deep valleys, and molded the changing shapes and global positions of continents and oceans. As the plates slowly move across the Earth’s surface, pushing together and pulling apart, volcanoes and earthquakes bear witness to the immense powers at play. Mountain ranges are thrust upward, only to be eroded by wind and water that deposit the eroded rock and debris in the valleys below. Change is constant in our world, especially over the very long intervals that geologists call “deep time.”

The Triassic Period in Nevada: 200 Million Years Ago

Nevada had both volcanoes and oceanfront property during the Triassic Period! Movement of the Earth’s crust during the Sonoma Orogeny created mountain ranges and volcanoes that sometimes blasted molten rock and ash across the landscape. The drawing at right shows reptiles with long spikes (aetosaurs) and huge amphibians (temnospondyls) emerging from a stream and prowling through a tropical forest during this period.

Shallow ocean water covered eastern Nevada when the Luning Formation was deposited in the area of Berlin-Ichthyosaur State Park (see map on previous page). Clams lived on the ocean floor. Whale-sized ichthyosaurs were the dominant predators of the Triassic seas. Ichthyosaurs may have preyed upon squid-like ammonites, eel-like conodonts, and perhaps the occasional unwary shark, as shown in the drawing on page 1. Ichthyosaurs at the Berlin-Ichthyosaur site are among the largest known, reaching up to 60 feet in length and weighing up to 40 tons! The Triassic oceans receded long ago, but marine rocks deposited by the seas preserved the fossilized remains of the ichthyosaurs.
**Complex Geology of the Berlin-Ichthyosaur Site**

Many scientists have studied the geology of the Berlin-Ichthyosaur site after a researcher from Stanford University identified the first ichthyosaur fossil there in 1928. Recently, paleontologist Marco Balini and fellow scientists carefully studied the site and created a stratigraphic column (below) and the geologic map (next page). Why is this information important? A stratigraphic column shows the thickness of rock layers, the types of rocks and fossils present, and the order in which the layers of rocks and fossils occur. Careful study of the sequence of rock types and fossils reveals the conditions that existed when the sediments were deposited (called “paleoenvironments”), and what life forms lived in those paleoenvironments. Comparing stratigraphic columns from distant locations helps geologists link the types of rocks and fossils to other areas across the Earth, enabling them to reconstruct Earth’s history!

Researchers determined that ichthyosaur fossils occur mostly in rocks named the Shaly Limestone Member of the Luning Formation (“members” and “formations” are rock layers that geologists have named). By knowing what the Luning Formation looks like and how thick it is, geologists know where to look for new ichthyosaur fossils.

A geologic map (see next page) shows the locations of different types of rock on the land surface. Sometimes the geology of an area is fairly simple, and sometimes it is very complex, like at the Berlin-Ichthyosaur site. A map legend uses symbols, patterns, and colors to identify the bedrock units on the map. The letters of the symbols tell geologists the name and age of each bedrock unit, and the patterns identify each bedrock unit on the map. According to the geologic map legend, the Shaly Limestone Member of the Luning Formation has the symbol “Trll.” Can you identify on the map where you might find other ichthyosaur fossils?

Can you tell how the stratigraphic column and the geologic map differ? The stratigraphic column identifies the types of rock present, the order of their formation, and their relative age (older on bottom, younger on top). The geologic map identifies each bedrock unit on the map with a symbol and pattern and displays where the different types of rock occur at the Earth’s surface. The stratigraphic column and geologic map together provide a detailed story of the geologic history of an area.

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**Stratigraphic Column**

<table>
<thead>
<tr>
<th>Volcanics</th>
<th>Cenozoic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbonate</td>
<td>Clastic</td>
</tr>
<tr>
<td>Luning Formation</td>
<td></td>
</tr>
<tr>
<td>Shaly Limestone</td>
<td>Triassic</td>
</tr>
<tr>
<td>Clastic</td>
<td></td>
</tr>
<tr>
<td>Grantsville Fm.</td>
<td>Limestone</td>
</tr>
<tr>
<td>Clastic</td>
<td></td>
</tr>
<tr>
<td>Pablo Formation</td>
<td>Permian</td>
</tr>
</tbody>
</table>

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**Stratigraphic Column Legend**

- Volcanic rock
- Marl
- Limestone, dolomite, marly limestone
- Argillite
- Siltstone
- Conglomerate
- Greenstone
- Ichthyosaur fossils
- Ammonite fossils
- Bivalve fossils
Using the map legend and the key below, color the geologic map of the Berlin-Ichthyosaur site.

- **Q**—Yellow
- **Tv**—Pink or red
- **P**—Purple and blue
- **Tr**—Green and teal

As you color, imagine the work that went into creating the map. To create a geologic map, we must hike and explore the area for exposed rocks. Rock samples, field notes, and photographs help put the geologic puzzle together. The map will show where different rock types meet. The order that rock layers were deposited is important. Sedimentary rocks with fossils help identify the layers and when they formed. If we know when an organism lived, we know when the rock was made. The many types of broken and faulted rocks on this map show the complex geology and history of Nevada.
The first records of fossils at the Berlin-Ichthyosaur site in Union Canyon were from the miners and their families living in the town of Berlin, though native peoples had likely seen them long before. Young boys even used round clam fossils as ammunition for slingshots. Miners found large bones in 1869, and sent samples to a scientist in Philadelphia, PA for study. In 1928, a professor at Stanford University identified the fossils as belonging to ichthyosaurs. Other scientists then traveled to Union Canyon to search for more fossils of these monstrous marine reptiles.

During 1954, Dr. Charles Camp began directing an extensive excavation of ichthyosaur fossils at the site. The first fossils of this expedition were found scattered on the surface. Paleontologists excavated a hillside where many bones were protruding, still half buried in the rock layers of the Luning Formation. The excavators carefully removed rock from around the fossil bones for many field seasons. Crews came back year after year, eventually exposing 16 skeletons in the main quarry location, as well as parts of 37 additional ichthyosaurs at other quarry sites throughout the park. Some skeletons were collected for museum study, but scientists realized the value of leaving many of the skeletons exposed in place. They asked politicians and land managers to have a protective structure built over the site. The State park preserves these fossils in place at its sheltered fossil exhibit.

**How Did the Fossil Ichthyosaur Quarry Site Become a Park?** The State of Nevada recognized the incredible value of the ichthyosaur quarry site and, in 1955, requested a permit from the USDA Forest Service to manage it as an education destination for the public. The new park was originally called “Ichthyosaur Paleontological State Monument.” When the State of Nevada acquired the nearby ghost town site of Berlin in 1970, it changed the name to Berlin-Ichthyosaur State Park. Oddly however, the fossil quarry site is not in Berlin, but rather at the site of the old town of Union. Settlers founded both the town sites of Union and Berlin within a year of each other, and both fledgling communities operated principally as mining camps. Over time, people came to know both towns as simply Berlin. The park uniquely preserves the geologic past and the mining history of Nevada, and is managed by the State of Nevada under agreement with the USDA Forest Service. Much of the property within the park, including the main fossil ichthyosaur quarry, are Federal lands of the Humboldt-Toiyabe National Forest.

Dr. Camp named the fossilized ichthyosaurs preserved at the site *Shonisaurus popularis*. The genus name, *Shonisaurus*, is after the Shoshone Mountains where Union Canyon is located. The species name, *popularis*, refers to a population of animals; it was chosen because many skeletons were found together in a mass death assemblage. In 1977, the Nevada State legislature designated *Shonisaurus popularis* as the Nevada State fossil.

The drawing on the right shows a reconstruction of how the ichthyosaur carcasses might have looked as they lay on the seafloor before burial. The drawing is based on burial positions of skeletons at the main quarry site. You can see why paleontologists wonder about the mysterious fate of all these *Shonisaurus popularis* ichthyosaurs!

**Are Shonisaurus Popularis Fossils Found Only in Berlin-Ichthyosaur State Park?**

No, ichthyosaur fossils have been found at other outcrops of the Luning Formation outside the park. However, the fossils at the Berlin-Ichthyosaur site are a spectacular and rare grouping of these large marine reptiles, and the only place where people can see large numbers of skeletons together still in their original burial position.
Ichthyosaurus Fossil Body Parts

Let’s take a closer look at the parts of an ichthyosaur fossil to learn more about these amazing reptiles.

The **Ichthyosaur’s Skull** looks a lot like a crocodile, with a long, tooth-filled jaw and openings on top of its snout for breathing air. Ichthyosaurs did not have gills like a fish, but breathed through their nostrils, as reptiles do. Like whales and porpoises today, an ichthyosaur could hold its breath for a long time as it hunted below the ocean’s surface for food.

The **Ichthyosaur Limbs** (arms and legs) evolved into flippers. Cartilage capped the bones, and ligaments and tendons held the bones together and allowed muscles to control them. Those soft tissues were similar to what you have along your arms and legs, including fingers and toes (digits). But flippers have no separate digits! Soft tissues enveloped by skin hold all of the digits together to make flippers, which are better than fingers and toes for maneuvering while swimming. That’s why scuba divers wear flippers on their feet!

The **Huge Eye Socket** (orbit) contains a ring of small bony plates, called a sclerotic ring, which helped the eye maintain its shape by resisting high water pressure when ichthyosaurs swam deep in the ocean. The huge size of the orbit and sclerotic ring tell us that ichthyosaurs had very large eyes.

**Ichthyosaur Vertebrae** (backbones) found at the Berlin-Ichthyosaur site are shaped like dishes or very large hockey pucks (below). A large number of very short vertebrae stiffened an ichthyosaur’s backbone. A stiff backbone helped the ichthyosaur focus energy from the powerful side-to-side swimming thrusts of its immense tail for underwater propulsion. Thick ribs attached to the vertebrae helped the massive ichthyosaur body retain its shape under high pressure while diving in deep water. The ribs nearly circled the torso and ended in a flat, spade-like shape that helped to support the internal organs.

The **Bones of the Tail** bend downward inside the lower part of the tail fin, and hard cartilage formed the upper part of the tail fin. This skeletal structure is similar to modern-day sharks that also have vertically oriented tail fins. Ichthyosaurs swam using powerful side-to-side pulses of their tail, similar to fish and other water reptiles. The modern-day group Cetacea (including dolphins, porpoises, and whales) are mammals, have horizontally oriented tail fins, and swim with up and down pulses of their tail.
OTHER FOSSILS FROM THE BERLIN-ICHTHYOSAUR SITE

Ichthyosaurs aren’t the only fossils found at the Berlin-Ichthyosaur site. Other fossils include ammonites, clams, tooth-like jaw parts of conodonts (ancient eel-like creatures), and many other marine organisms. Although these fossils may seem less spectacular than the massive ichthyosaur skeletons, they provide valuable evidence of the ocean environment and ancient marine communities where ichthyosaurs lived.

Ammonites are an extinct type of mollusk that resembles a squid inside a coiled shell, similar and related to today’s nautilus. The shell had small air chambers that helped an ammonite move up or down in water, like a submarine. The head and tentacles extended out of the shell’s opening. The drawings on the right show a typical ammonite found at the Berlin-Ichthyosaur site (seen from the side and the back). The ammonite could rocket through the water, much like a modern-day squid, by using bursts of water shot through a special tube, called a “siphuncle.”

Conodont fossils are very small and look a lot like tiny teeth. The only fossilized parts of the conodont animal commonly found are their jaw parts (conodonts), but they are thought to have looked like miniature eels or worms living in the oceans. The drawing on the right shows enlarged views of the same tiny conodont fossil (jaw part) from three different angles.

Fossilized clams (called “bivalves” by biologists) nestled into the sediments on the ocean floor and fed on small organic particles in the water by filter-feeding. The drawing on the right shows a fossilized clam from the Berlin-Ichthyosaur site.

THE EERIE FATE OF THE ICHTHYOSAURS AT THE BERLIN-ICHTHYOSAUR SITE

Scientists love a mystery! The fate of the ichthyosaurs seen in the main display building, called the Fossil House, present a true puzzle. Here are the facts:

1. All ichthyosaurs within the Fossil House are articulated skeletons, meaning individual bones are preserved joined together.
2. Many of the ichthyosaur skeletons lie in parallel rows.
3. All of the ichthyosaur skeletons are large adults.
4. All the fossils are preserved in the same condition.
5. A lot of ichthyosaurs died together at the site, estimated at 9 to 14 individuals (because some skeletons are incompletely preserved).

Scientists research every fact and study every clue for ways to explain these mass burials. This research is called taphonomy, which means studying the factors that acted on a fossil before it was preserved.

Dr. Charles Camp, the first scientist to excavate and study the Berlin-Ichthyosaur fossil quarry, thought the parallel ichthyosaur remains were beached together in shallow water. This early hypothesis (an explanation based on facts) could explain the alignment of the ichthyosaurs in a group. However, the nearby rocks are missing sedimentary structures that commonly develop in shallow water. This indicates the ichthyosaurs likely died in deeper water. Other hypotheses suggest the ichthyosaurs died and were buried in a toxic environment (perhaps related to an algal bloom) or were poisoned by eating toxic organisms. Paleontologists understand that these are still just hypotheses. Some fit the evidence better than others, but there is still no agreement on a single explanation for the mysterious death and burial of these ichthyosaurs.

A unique idea is that a giant squid (or “kraken”) carried the ichthyosaurs to its lair and aligned the bodies. This idea has no facts to support it, aside from modern observations that squid and octopuses...
attack other sea life and sometimes manipulate stones or shells on the ocean floor. No evidence of a giant squid is known from the Luning Formation. Fanciful tales of a giant kraken may capture the imagination but should be viewed as science fiction rather than a scientific hypothesis.

Sometimes being wrong in science tells you as much as being right, by leading you in a new direction. Dr. Camp carefully documented the ichthyosaur site and created a theory that he believed explained the death assemblage. Other paleontologists who carefully studied rocks and other fossils at the site disagree with Dr. Camp’s theory. The scientific method is the pathway to solving scientific mysteries. Scientists make careful observations, take detailed notes, think creatively, and arrive at explanations based on their findings. Other scientists may add their own findings and come up with new solutions. Sometimes the answer remains a puzzle, as in the mysterious death assemblage at the Berlin-Ichthyosaur site, but that doesn’t stop dedicated paleontologists from trying to solve the scientific riddles.

We do know that all these ichthyosaurs are buried closely together. That means they likely died closely together from the same cause. A logical explanation for this fact is that the animals lived in social groups. We see this in sea animals today, such as dolphins and whales. This idea of social behavior is another hypothesis based on facts from the Berlin-Ichthyosaur site. Some scientists accept this hypothesis as scientific fact.

**Activity: Excavation Puzzle**

The excavation crew has been hard at work uncovering a new ichthyosaur fossil bed, but they find fossils all around the quarry site. Can you help them identify each fossil they find? Put the letter for each part of the fossil next to the appropriate fossil drawing but look carefully; each drawing may show more than one fossil part. Answers are on the last page of the booklet.

- A. Skull
- B. Vertebrae
- C. Rib with vertebrae
- D. Tail
- E. Paddle bones
- F. Sclerotic ring bones
- G. Rib bones broken and moved by a fault
Parallel Pathways of Life: Different Ways of Looking Alike

Look at the illustrations below of the ichthyosaur, orca (killer whale), and shark. They look a lot alike, but they are totally unrelated! All three are marine predators with dorsal fins midway down their backs, but one is a reptile, one is a mammal, and one is a fish. Both the ichthyosaur and orca evolved from land animals that returned to the ocean. Over millions of years, each group evolved fish-like body types through a process called “convergent evolution.” Convergent evolution means different creatures developing similar body parts when they live in the same type of environment. A fish-like body is best for survival when living in a water environment. Another example of this is flight. Bats, a group of mammals, and birds have very different wings but accomplish the same ability to fly through the air.

Let’s take a close look at the details of how these ocean predators differ, even with their similar body shapes. The ichthyosaur breathed air through nostrils, had four flippers (two in the front and two in the back), and a vertical tail fin. The orca breathes through a blow hole on top of its head, has two flippers (in the front), and a horizontal tail fin. The shark has gills that pull oxygen from the water, so it does not breathe air at the surface like orcas and ichthyosaurs. The alignment of a shark’s tail says a lot about how this animal swims. Marine mammals like the orca swim with a powerful up and down tail motion, while ichthyosaurs swam like sharks, by moving their tails side to side. All three creatures are (or were) fierce sea-dwelling predators, but they are completely different and unrelated animals that evolved similar features to be successful underwater.

Activity: Create a Creature

Use the space below to draw your own giant ocean predator. Be sure to include how it swims, how it breathes, and what it likes to eat.
The ghost town of Berlin is another fascinating feature at Berlin-Ichthyosaur State Park. The old town is in ruins, but still tells the history of early mining in Nevada. Mining in this area began in 1863 with the discovery of gold in nearby Union Canyon. The town of Berlin was founded in 1897 near the gold mines, and by 1905, Berlin boasted a population of 300 people. All kinds of people, not just miners, make up a mining town. Berlin’s citizens included woodcutters, charcoal makers, a doctor and a nurse, families, teachers, and shopkeepers. The Shoshone Mountains east of Berlin provided timber and building materials for both the Berlin and nearby Diana underground mines. The prospectors of Berlin were the first to collect ichthyosaur fossils and send them to a paleontologist for identification.

In 1898, the Nevada Company bought the Berlin and Diana Mines and other nearby mining claims. The company mined gold and silver from these sites. The Berlin mine produced about $849,000 worth of gold (when gold was worth $20 an ounce). Wealth and riches from mining were eventually exhausted, and mining in the Berlin area slowed during the early 1900s. By 1911, the citizens had abandoned the once-thriving mining town. Many of the old buildings still remain, and Nevada has protected the ghost town in an effort to preserve that fascinating history. Visitors to Berlin-Ichthyosaur State Park can walk around the old town site and visit its cemetery. Try to imagine living the life of a miner in the vast, open expanse of central Nevada. The illustrations below show some of the tools a miner in Berlin might have used. These include an ore cart, a shovel, a rock hammer, a chisel, a gold pan, and a pick axe.

**WHAT WOULD YOU DO IF YOU FOUND A FOSSIL OR ARTIFACT?**

Think like a scientist! Take a photograph or make a sketch of the object in your notebook. Take notes of the location where you found it and record details of the surrounding area. Is the object still embedded in rock? What does the rock look like? Report what you find to the nearest Forest Service office. You may have just discovered the next famous ichthyosaur site!
Activity: Word Search

Find the following words in the puzzle below. Answers are on the last page of the booklet.

BASIN
NEVADA
CENOZOIC
PYROCLASTIC
MESOZOIC
REPTILE
PHANEROZOIC
RANGE
BERLIN
FAULT
PALEozoic
EYE
PROspector
BASIN
EV
oprozoic
RANGE
berlin
Fault
Paleozoic
EYE
Prospector
PLAYA
CONODONT
CARTILAGE
Quarry
KRAKEN
MINE
EXCAvATION
KRAKEN
Landform
ICHThYSaur
triassic
Ammonite
FossiL
Volcano
OROgeny
Flipper
Rib
Stratigraphic
Formation
Bedrock
Precipitation
E T I N O M M A A Y E B T S C E N O Z O I C
G R P W S E G N A R E U F K R A K E N K
A P Z E R E X H Y E S R E C B R W U B
A C X O O L H R Z R P M N L T O B K R G
D I F C Y L L I K R O P S S L I T G R U J Q
A R U A S O Y H H C I P U C N D N D U K
V I R V H O N R Z P K L A H E X B I L A E J
E V W A J C Y L A E E F U P N E S T R T P B
N O I T A M R O F G E R S S Y A F R C T I K
U J R I L Y N E G O R O Q K B L Y A A R R L
N R AN O U A A L P R E C I P I T A T I O N
V O L C A N O J S H S S Y L N D K X I F L H
C I H P A R G I T A R T S E V H X Q L L L A
I T S W M E A U I N A E R Y T E S O A T I T
Z L A O R K Z M P R A U T S U L D R E O S I
O N T S A L I S S O F D L L S F T K D C A
E Z O Y T L N J S Z T U L B O K E T E O A S
L U A N L C I O Z O S E M R T F L Y E N U S
A L R T C D K V K I R A M T S I E A E O S I
P K A Y S P Y R O C L A S T I C X A U C Y C
**Activity: Coded Messages**

Decipher the messages below. Each letter in the alphabet represents another letter. Write your answer below the code. A clue is given at the bottom of the page. Answers are on the last page of the booklet.

**Message 1:**

```
LB, URKBGXO UKYF UJELWUAXL BXOXKBUR KA ARX
```

```
NURARCJOKWB DWKBBC VJB JHXB AMXEAC CXKBO
```

**Message 2:**

```
SAQ NXASAKWBZFL DFZLLK NB VQBNPYZSQV
```

```
ZB Z LQPNBSQLQV YZSNWYZJ JZYVUZLC
```

**Activity: Scrambled Words**

These words from the Berlin-Ichthyosaur activity booklet are scrambled. Unscramble all the words. As a hint, there is a drawing for each word. Answers are on the last page of the booklet.

1. DOOCTNN
2. YTUHRISCOA
3. NLOOAVC
4. DDLPAE NOBSE
5. TSCCIEORL GRIN
6. SAATUOER
7. EANTMOMI
8. MLAC
9. LHVOSE
10. EEBETRRVA

Message 1 clue: "R" represents the letter "H." Message 2 clue: "N" represents the letter "I."
**EXCAVATION PUZZLE:**

A. Skull  
B. Vertebrae (two sets)  
C. Rib with vertebrae  
D. Tail  
E. Paddle bones (two sets)  
F. Sclerotic ring bones (two sets)  
G. Rib bones broken and moved by a fault

**WORD SEARCH:**

```
ETINOMMACAYEBTSCENOZOIC
GRPWBTSEGNAREUFKRRAKENK
APZEREXWLDYESRKECBRWUB
ACHXOOLHRZRPMLTTOBKRG
DIFCYLILKROPSLITGRUJO
ARUASOYTHCIPUCCNDNGBK
VIRVHONRZPKLAIHEXBLAEJ
EVWACYLAAEFUPNFSESERTPB
NOITAMROFGESSYAFRCRTIK
UJRILYNEGROQKBLYAAARRL
CBNOAMEFOLRTZQUMKRHIP
NРANOUAALEPICATION
VOLCANOJSHSSYLNKXIFLH
CIHPARGITARTSEVHXOLLALA
ITSWMEAUIAERYTESOATIT
OCHLJVERTEBRAEHKXNGPR
ZLAORKZMPRATUSDREOSI
ONTSAALISSOFDDLSFTTKDCAN
EZOYTLNJSZTULBOKETOAS
LUANLCIOZOOSEMRFTLYEUSD
ALRTCDKVKRAMTSIEAOEASI
PKAYSPYROCLASTICXAIUCY
```

**CODED MESSAGES:**

Message 1: Dr. Charles Camp conducted research at the ichthyosaur quarry for over twenty years  
Message 2: The ichthyosaur quarry is designated as a registered national landmark

**SCRAMBLED WORDS:**

1. CONODONT  
2. ICHTHYOSAUR  
3. VOLCANO  
4. PADDLE BONES  
5. SCLEROTIC RING  
6. AETOSAUR  
7. AMMONITE  
8. CLAM  
9. SHOVEL  
10. VERTEBRAE

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