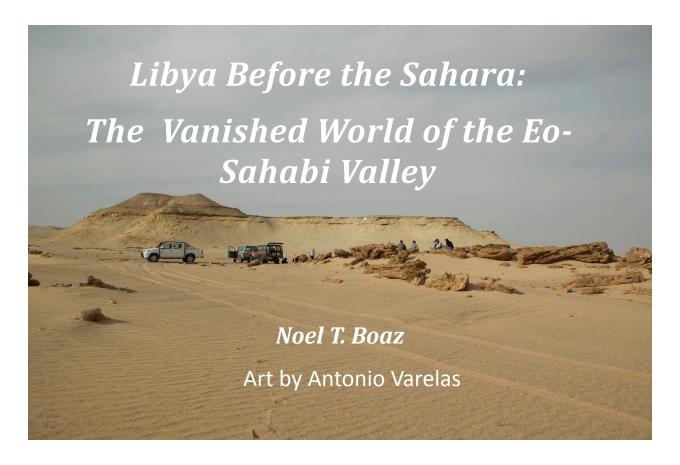




Hominem sapientia pro Hominibus



Libya was once a lush forested savanna with prolific grasslands flanking one of Africa's great rivers. Encroaching Saharan sands and mountain-building that cut off the flow of water wiped out a diverse fauna and flora. Somehow hominids survived.

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Cover photograph: As-Sahabi Locality P28 and the "petrified forest" fronting Garet Makada ("Elephant Hill"), west of Sebkhat al-Qunnayyin, Libya.

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Today when one drives south from the Libyan coast into the Sahara Desert, it is hard to imagine what the scenery might have been like before sand blanketed the landscape. Today plants and animals are sparse. Except for the palms at isolated oases, there are no trees. The animals that one sees, such as camels, goats, and the occasional dog, are not native to the desert but are domesticated species brought in by humans. In fact, over 90% of Libya's land is desert. But it was not always like this.

Once a great river flowed through Libya – like the Nile in Egypt, the Niger or the Congo in western Africa, or the Zambezi in southern Africa. It is called the Eo-Sahabi River. The river was surrounded by many wild animals. Chattering birds, monkeys clambering in trees, and hippos basking in the sun lived along the river. On the open plains extending inland, there were herds of antelopes and three-toed horses, hyenas, sabertooth cats, pigs, and many other species. Our scientific teams have discovered the fossilized bones and teeth of all these animals in this now-vanished world.



The fossil site of As-Sahabi is located in North Central Libya at the northern edge of the Sahara Desert.

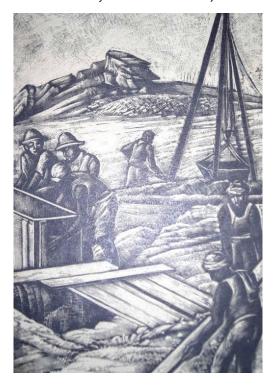
Where did all the water in the ancient river come from and where did it go? What happened to the many animals and plants that lived in Libya millions of years ago?

The site of As-Sahabi in North Central Libya, one of Africa's great fossil sites, has given us a window into this very different world and has enabled scientists to answer many of these questions. Geological and paleontological research has been going on at As-Sahabi since the mid-1970's and continues today. Exhibits on the exciting fossil discoveries from this site can be seen in the Earth Science Museum at Garyounis University in Benghazi, where our East Libya Neogene Research Project is based, and at the National Museum of Libya in the Sarayy al-Hamra in Tripoli.

The Site of As-Sahabi

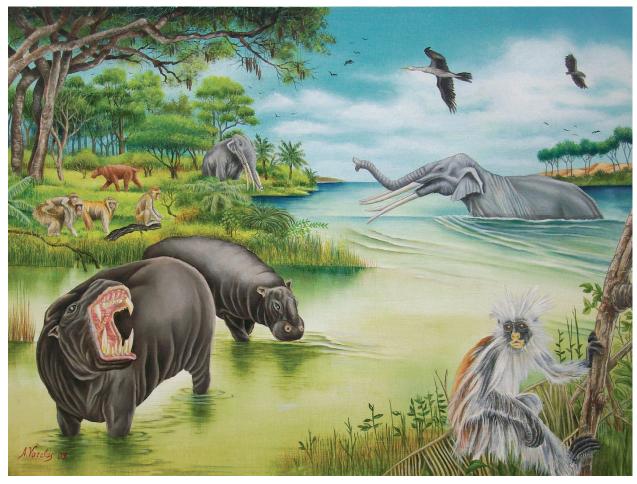
The site of As-Sahabi first became known not as a window to the past, but for window panes. When Libya was a part of the Roman Empire, around 100 B.C., the site was an important source of large crystals of gypsum or selenite, used for constructing window panes in Roman buildings. We now know that this gypsum was deposited in an ancient lagoon in an embayment of the Mediterranean Sea. A fort near a small oasis was built by the Romans to guard the gypsum mining operation from marauding Berbers. After the Romans left Libya the fort of "Qasr as-Sahabi" was taken over and enlarged by Byzantine, Turkish, and Italian armies. It was largely destroyed during the Second World War but the outlines of its walls are still to be seen today.

Italian soldiers stationed at Qasr as-Sahabi were the first to find fossils in the region. They informed famed Italian geologist Ardito Desio, the same man who first discovered oil in Libya. Desio recruited a young paleontologist named Carlo Petrocchi whose discoveries in the 1930's would make As-Sahabi the most



Left. Excavation and removal of the skeleton of the four-tusked elephant, *Stegotetrabelodon syrticus*, at As-Sahabi in 1934, as depicted by Carlo Petrocchi in 1951.

Below. The habitat of the riverine forest and river edge. The As-Sahabi six-fore-toothed hippo (Hexaprotodon sahabiensis) is in the left foreground two As-Sahabi four-tusked elephants (Stegotetrabelodon syrticus) are in the background. The rare As-Sahabi colobine monkey is in the right foreground while a group of the more common macaque-like cercopithecine monkeys (Parapapio sp.) is seen in the left middle ground, lounging under a sausage tree (Kigelia). One of two species of bear at Sahabi (Agriotherium africanum), Africa's earliest, ambles through the left background. A darter (above center) and eagle (above right) fly above the river looking for fish.



famous Libyan fossil site. Petrocchi's first major discovery was his best - a virtually complete skeleton of a previously unknown elephant. Incredibly, this species had not two but four! It was named tusks, Stegotetrabelodon syrticus, meaning "fourtusker from Sirt" [the Libyan gulf]. Excavating, hardening with glue and plaster, and crating the fossil skeleton for shipment was a huge undertaking, but when it arrived by truck in Tripoli it created a sensation. The colonial Italian governor-general of Libya established in Tripoli an entire museum - the Libyan Museum of Natural History - with the As-Sahabi elephant fossil as its centerpiece. This museum only survived a few years but it was the forerunner of today's Libyan National Museum. The famous Stegotetrabelodon is still there in the old museum building in Sarayy al-Hamra. Over the years it has been featured on two Libyan postage stamps and is considered by those who remember him as Libya's "national fossil." This unique witness of Libya's ancient past is awaiting a new and better home in the national museum where Libyans and tourists alike can visit him again.

The Underwater Habitats: Freshwater and Saltwater

As amazing as it seems to a casual visitor to the As-Sahabi desert today, all the rock and blowing sand were originally brought there by water. Wind has sculpted the rocks and moved the sand around but it was the ancient



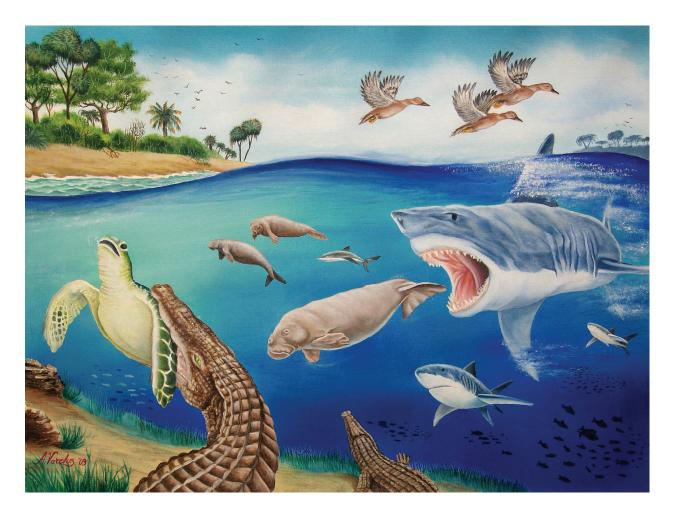
The freshwater habitat in the Eo-Sahabi River. A large widehead catfish (*Clarotes laticeps*) and a school of bichirs (*Polypterus*) swim near the river bottom. A group of crucifix catfish (*Arias*) swims in the middle foreground. A spotted sqeaker catfish (*Synodontis*), catfish (*Clarias*), and Nile perch (*Lates nilotica*) swim in the left middle ground. The long-snouted crocodilian *Euthecodon* has just captured a Nile perch. Two iniid river dolphins swim in the left background, while in the right background sparid sea bream and the bottle-nosed dolphin *Lagenorhynchus* swim out seaward toward estuarine waters.

Eo-Sahabi River and its adjoining lagoons and estuaries of the Mediterranean Sea that laid down the sediments of what we now call the Sahabi Formation. The animals which lived in those waters were abundantly preserved as fossils. These animals were primarily fish, and most of them were species that today live in freshwater.

The underwater freshwater riverine habitat preserved at As-Sahabi is what fossil workers call the "proximal" (nearby) burial

environment. The fish fossils buried at As-Sahabi were the native species that lived there. The sedimentary rocks preserving the fossils represent the same environment in which the fish lived when they were alive. We call such a collection of bones "autochthonous" — their habitat during life and their burial environment were one and the same.

The fish fossils tell us much about the Eo-Sahabi River. The sizes of the preserved fish



The saltwater underwater habitat in As-Sahabi lagoonal embayment. A *Crocodilus checchii* preys on a sea turtle (*Trionyx triunguis*) in the left foreground while great white sharks (*Carcharodon megalodon*) swoop down on a group of sea cows (*Metaxytherium serresii*). Above, a group of geese flies out over the water.

bones are generally large, indicating that the fish were big and were living in a major river with a lot of food resources and a lot of room for them to live to old age. Just from the evidence of its fish fauna, we know that the Eo Sahabi was a large and perennially flowing river.

The species of fossil fish at As-Sahabi are also found today in Lake Chad, the Nile River to the east, the Congo River to the south, and the Niger River to the southwest. Usually rivers share species because they were connected in the past. As-Sahabi shares the most species with Lake Chad, indicating that this connection was the closest and most important. Even without physical connections though fish can be transported from one river basin to another by birds. Fish-eating birds, such as eagles and darters, both known as fossils at As Sahabi, may carry fish through the sky for kilometers and may drop them by accident in a different river drainage system. Wading birds, such as storks, also known as fossils at As-Sahabi, may transport fish eggs from mud on their feet from one river system to another. The percentages of fish species shared between the Eo-Sahabi and the other great regional African rivers decrease from the Nile to the Congo to the Niger, correlating with each river's geographic distance away. It is most likely that bird transport of these fish species accounts for this pattern of distribution. Outside of the Eo-Sahabi River-Lake Chad system, the Nile River is the closest geographically and shares the most fish species.

Other, air-breathing, animals shared the Eo-Sahabi freshwater habitat with fish. A species of extinct long-snouted crocodile, the euthecodon, had specialized jaws for catching fish. It is also found at fossil sites in the Nile and Congo River drainages. Two fish-eating aquatic mammals swam among the fish. A species of river dolphin, now extinct in African rivers, and a fossil harbor seal, now extinct in

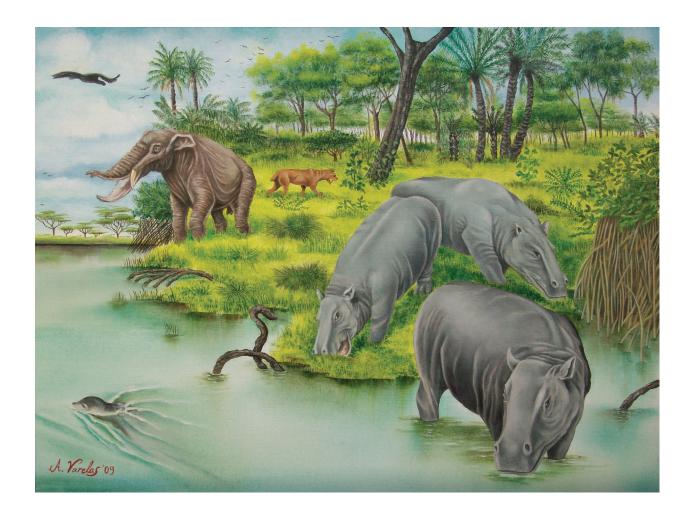
the Mediterranean Basin, lived in the Eo-Sahabi River and estuary.

As the Eo-Sahabi River wound its way to the sea it widened out into embayments, estuaries, and lagoons. These bodies of water had a higher salt content than the river itself and supported a community of animals different from the freshwater river itself. Fossils from this habitat are found preserved in different sedimentary rocks - white strata dolomite deposited under lagoonal conditions. Some small marine fish such as sea bream (sparids) are found here but they are rarer than are the fish in the riverine deposits. The most common fish in the lagoons were big sharks, in fact the biggest species of all, the great white shark (Carcharodon megalodon). The paleontological evidence at As-Sahabi shows great white shark teeth among the abundant skeletal remains of sea cows (Metaxytherium serresii), whose distinctive puffy ribs show the deep gashes of shark attacks. The vegetarian sea cows grazed at As-Sahabi on extensive beds of sea grass (Posidionia) that grew around the margins of the Mediterranean Basin. The same sea cows are found in similar-aged fossil deposits in southern France.

A unique fossil crocodile (Crocodilus checchii) that was first discovered at As Sahabi had a distinctive raised bump on its snout. Living crocodiles in Cuba have a similar bump that houses a gland that secretes salt, adaptation that allows this species to range into salt water. Fossil remains of the As-Sahabi sea turtle (Trionyx triunguis) show the unmistakable bite marks of crocodiles and were probably a favorite food. Another of dolphin (Lagenorhynchus) discovered at As-Sahabi is related to living dolphins who are adapted to marine coastal habitats worldwide but went extinct when the Mediterranean dried up after As-Sahabi times, about 5 million years ago.

A Contrast of Terrestrial Habitats— Swamps and Deserts

The many fish in the underwater habitat of the Eo-Sahabi River would have been used to seeing the feet of the air-breathing animals who shared their environment. These were hippos, four-tusked and shovel-tusked probocideans, and the occasional antelopes, pigs, carnivores, and other obligate land animals that waded in. But the most common air-breathing animals in the aquatic environment were undoubtedly anthracotheres (literally "black beasts" because their first fossils were found in European coal deposits). Anthracotheres were swamp-forest-dwelling, pig-like animals widespread in the fossil record of Eurasia and Africa and found in sites in which environments were wet, warm, forested, and swampy. Interestingly, anthracotheres were



A group of anthracotheres (*Libycosaurus petrocchii*) feed on lush swamp grasses near the water's edge while a harbor seal swims by into the Eo-Sahabi estuary. In the middle ground another denizen of the Sahabi swamps, the "shovel-tusker" proboscidean (*Amebelodon cyrenaicus*) forages. In the background can be seen the sabertooth *Amphimachairodus* aff. *kabir*.



Over half of the small-mammal fauna from Sahabi is the arid-adapted gerbil *Abudhabia yardangi*, providing a stark contrast with the wet-adapted anthracotheres. A ground squirrel (*Atlantoxerus getulus*) looks out from its perch on a rock outcrop.

close companions to the ancient apes that are found in the tropical forest fossil sites of Africa and Asia pre-dating As-Sahabi, suggesting that their habitats shared significant ecological similarties. The anthracothere *Libycosaurus* is the most abundant large mammal at As-Sahabi even though the impressive four-tusked elephant *Stegotetrabelodon* is the most well-known.

Despite their abundance at As-Sahabi, anthracotheres were a dying breed. As-Sahabi and the closely related site of Toros Menalla in Chad, dated to the late Miocene about 6 to 7 million years ago, preserve the latest fossil record of the group in Africa. African anthracotheres went extinct worldwide shortly thereafter. Big and bulky, *Libycosaurus* were the largest of their kind. To sustain their body mass their teeth became a virtual buzz-saw of cutting blades processing massive quantities of soft marsh plants. They were unique among all other modern mammals in adding a fifth premolar to their impressive battery of teeth.

The paleontology of the As-Sahabi anthracotheres tells an important story of

environmental change. Unlike other earlier anthracothere habitats, As-Sahabi does not preserve coal forests or lignites. There were large trees at As-Sahabi forming a riverine forest but the widespread and dense tropical forests that had once covered wide areas of Africa had disappeared. Some trees at As-Sahabi even show scarred rings caused by savanna bush fires. Half of the small mammals that have been found at As-Sahabi are dryadapted gerbils, showing that open country and probably even incipient desert conditions were only a short distance away. The species Libycosaurus petrocchii apparently did not luxuriate in a swamp forest as had its ancestors but held on for dear life in the marshlike fringes of a major African river surrounded by encroaching desert. Its lifeline was the Eo-Sahabi. When the river dried up, the African anthracotheres would disappear forever. The anthracotheres tell us, in context with the rest of the As-Sahabi fauna and flora. that there were rapid and major habitat transitions in the latest Miocene of North Central Africa – swamp forest to near-desert within a distance of only a few hundred meters.

An Ancient Bioprovince and A River that Ran Through It

Unlike the rest of Africa, northern Africa borders the Mediterranean Sea, and a good part of its environmental uniqueness derives from this fact. Beginning about 7 million years ago during the Messinian stage of the late Miocene Epoch, the Mediterranean Sea began to evaporate, probably due to a cutting off of inflowing waters from the Atlantic Ocean at Gibraltar. Like a giant bathtub with the faucet turned off, the Mediterranean Basin cooked in the hot sun until large parts of it were a parched, salt-flat desert. This was a land bridge between Africa and Eurasia but not one that many animal species could cross. Stegotetrabelodon was one animal which did cross the Mediterranean Basin. Its fossil remains have been found at the southern tip of Italy.

Dry conditions spread generally across northern Africa, the incipient Sahara Desert, as the region fell into the giant rain shadow of the uplifting Himalayas far to the east. Life huddled around life-giving rivers that flowed out of tropical Africa to drain into the Mediterranean. Because of these isolating environmental conditions, North Central Africa preserves a unique Libyco-Chadian fauna at this time. There are many endemic species, led by Libycosaurus petrocchii, a species absent from contemporaneous fossil sites in other parts of Africa. Some species, the ones that could disperse across open country, could migrate out of the region and are found elsewhere. Most of the animals at As-Sahabi that are shared with other fossil sites in Africa and Asia are the carnivores like and hyenas, savanna Stegotetrabelodon, open-country ungulates like antelopes and three-toed horses, and dryadapted rodents like the As-Sahabi gerbil. It is at first surprising that hippopotamuses are one of the groups from As-Sahabi that are shared with other sites in Africa, but unlike the water- and marsh-bound anthracotheres, hippos are grazers that easily walk over open country for many kilometers looking for grass. The ancient primate co-sojourners of anthracotheres must also have undergone severe selective pressures as forests shrank and food resources dwindled.

The Habitat of the Plains

As-Sahabi records the transition away from the ancient African forests to the brave new world of the plains and savannas. If we imagine ourselves leaving the river bank after a refreshing drink in the Eo-Sahabi river, we would soon pass through the riverine forest, emerging to see before us the extensive grasscovered plains of Africa. Here only acacia trees and low bushes sparsely dot the landscape but there are many mammals to be seen. The animals of the African plains are for the most part cursorial - they have limbs and bodies with running adaptations. The habitat that they inhabit would be familiar to us today because it spread widely in Africa after the late Miocene as climate generally became drier over most of the continent. Although there are no more habitats like this in northern Africa, the Serengeti Plain in Tanzania, Virunga National Park in the Democratic Republic of Congo, and Kruger National Park in South Africa would be quite similar.

Paleontologists term the fauna from the plains habitat at As-Sahabi the "distal" community because it is far away from the actual site of water-laid fossil deposition. Fossils of these animals must be "brought in" – by the action of flowing water or by the scavenging activities of other animals. Despite this transport, which leads to fossils from the plains being generally more fragmentary than those from the near-river community, most of the species



The open country or "savanna" habitat at As-Sahabi during the rainy season. A group of *Pachycrocuta* hyenas scavenges a kill of the antelope *Miotragocerus* in the foreground, as the small carnivore *Viverra howell* looks on. Maribou storks and two running hyenas (*Chasmaporthetes*) keep their distance from the kill. A shallow water hole is a focus for plains animals and has attracted hippos (*Hexaprotodon sahabiensis*), *Dytikodorcas lybicus*, the most common As-Sahabi antelope (right), hippotragines, and *Raphicerus* (left). The running savanna hog (*Nyanzachoerus syrticus*) is shown in the middle right foreground. A group of three-toed horses (*Cremohipparion*) gallops in the left background. A hypothetical group of *Sahelanthropus*, a yet -to-be-confirmed "ghost species" at As-Sahabi, rests in the shade of a *Celtis* tree.

diversity at As-Sahabi is paradoxically from this habitat. This is a testimony to how biologically productive the teeming plains of Africa had become. Antelopes were the most numerous large-mammal denizens of this habitat. The most common antelope at As-Sahabi was the antilopine *Dytikodorcas lybicus*. Antilopines are open-country antelopes in Africa today. Most of the other antelopes belong to open-country or bush-adapted groups. Signifi-

cantly there are no forest or dense bush antelopes known. Three-toed horses of as many as four species are present at As-Sahabi. Not as large or as fast as the single-toed zebras of today, their limb anatomy and high-crowned chewing teeth indicate that they frequented the open spaces and grazed on the tough grasses that grew there. A running hyena (*Chasmaporthetes*), whose limb proportions resembled those of the modern cheetah, and a pig with long legs (*Nyanzachoerus syrticus*) were also species which had adapted to covering large territories in their quests for food in the vast open plains. Primitive giraffes and rhinoceroses lived here too but were rare.

Ghosts at As-Sahabi

There are some animals that we know must have been present in the ancient habitats at As-Sahabi but whose fossil remains we have not yet discovered. Until their presence is confirmed we may well term these animals "ghosts" - shadowy creatures whose actual existence cannot be proven. One example of such a ghost species at As-Sahabi is owls. These birds hunt by night and feed on small mammals. They then nest during the day in trees (near the river) where they disgorge "pellets" containing all the indigestible teeth and bones of their prey. Owl pellets are almost certainly the sources for most or all of the small mammal fossils that we have discovered from the distal plains habitat at As-Sahabi. We have the owls' signature in the fossils but not their actual remains.

Another category of ghost species includes species whose habitats are present at As-Sahabi, whose fossil antecedents are present elsewhere at earlier fossil sites, and which have modern descendents in Africa. A prime example of these ghosts are prosimian primates. We have discovered a forest-living insectivore, a shrew, at As-Sahabi, and we have the fossil wood that documents the presence of forest trees. But so far fossils of small nocturnal ghost-like primate species like the living African bush baby have eluded us.

A third category of ghosts are rare species that have been found at other sites that just by chance or bad luck have not yet turned up at As-Sahabi. Dogs, rabbits, and aardvarks are plains animals discovered at the late Miocene Chadian site of Toros Menalla, to the south of As-Sahabi, of similar age, and connected to it

by the Eo-Sahabi river drainage basin. We hypothesize these species to have been at As-Sahabi but so far have not found them.

Certainly the most talked-about As-Sahabi ghost species is hominids, the bipedal ancestors of ourselves. A few fragmentary fossils that might be apes or hominids have been found at As-Sahabi but they are not definitive. A skull of the earliest known hominid, Sahelanthropus tchadensis, was discovered in 2001 at Toros Menalla, around the headwaters of the Eo-Sahabi river in Chad, strengthening the case for hominids as a ghost species at As-Sahabi. But what kind of ghost species would the earliest hominids be? Unlike owls, hominids would not likely have left a paleontological signature of their presence. But are they similar to the bush babies, living in the riverine forest close to the anthracotheres, the ecological companions of their ape ancestors, or are they out on the plains with the rare dogs and rabbits, carried there by their new method of locomotion, bipedal walking? Only time and much more fossil exploration of the fossil sediments at As-Sahabi will tell. What is clear is that hominoids of whatever ilk would have had to adapt to profound changes in late Miocene environments or go extinct. As-Sahabi may eventually tell us much about the earliest evolutionary emergence of our hominid ancestors.

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