Rise of Lost Worlds
Part 4: Kokoro's Robotic Animals in the Cultural History of Dinosaurs in Japan

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Introduction

Under a dark sky, amidst fluttering lightning, a silhouette rose up. It was a huge silhouette indeed, with a terrible mouth full of fangs. It raged, roared and came towards us, shaking the ground. It must be Godzilla—no, it was a tyrannosaur!

This was the scene at the Dinosaur Exploratorium (1993–2006) at the UNESCO Village in Saitama Prefecture near Tokyo. Visitors travelled by boat through time, from the very beginning of life to the end of the Cretaceous period, winding through a world filled with hundreds of robotic animals from ancient times. Present-day viewers of the photographs and films from the exhibit would be struck by the sheer number of robotic animals and the detail and artistry of the landscapes. Coelacanths swam in a beautiful blue sea, countless amphibious *Ichthyostega* crowded the shore and a carnivorous

Dimetrodon watched a large herd of herbivorous *Edaphosaurus*. *Stegosaurus* grazed peacefully among cycads bathed in the sunset. A blood-red moon illuminated the dark ocean, where the necks of *Elasmosaurus* soared through the water. In another scene, *Maiasaura* parents nursed their young on dry land. Beneath the thunder and lightning that heralded the end of the dinosaurs, a group of *Deinonychus* dug their claws into the body of a poor *Tenontosaurus* while a family of *Triceratops* defended their child from a menacing *Tyrannosaurus* (Figure 1).[1)]

The Dinosaur Exploratorium was designed and built by Kokoro (ココロ). Founded in 1984, the Kokoro company supplies robotic characters and animals to amusement parks, department stores and museums. When I first read about the Dinosaur Exploratorium, I noted that it opened in 1993 and assumed that it

Figure 1. The *Tyrannosaurus* and *Triceratops* at the Dinosaur Exploratorium (*Kokoro News.* 50. February 1994, 4–5)

was likely hastily planned and constructed to take advantage of the massive success of Stephen Spielberg's film *Jurassic Park*. However, after interviewing Kayako Kido 木戸佳弥子 at Kokoro and conducting document research, it became clear to me that the Dinosaur Exploratorium had been planned independently of Spielberg's film. Indeed, I came to conclude that the Dinosaur Exploratorium was, in fact, the culmination of Japanese dinosaur culture, which has its roots in the 19th century.

Therefore, in this essay, I introduce the robotic dinosaurs created by Kokoro and its predecessor, Tokyo Design Kogei（東京デザイン工芸）. I also describe the evolution of Japanese dinosaur culture. For this purpose, I have consulted over 220 articles mentioning dinosaurs published in the major Japanese newspapers *Yomiuri Shinbun*, *Asahi Shinbun* and *Mainichi Shinbun* from 1904 to January 1994. I also examined 19 newspaper articles related to Kokoro and Tokyo Design Kogei, as well as 48 issues of *Dokoku News* and *Kokoro News* published by Kokoro and Tokyo Design Kogei. Finally, I examined books on dinosaurs published in the 19th and 20th centuries. Additionally, the writings of Hiroshi Tamura 田村博, a jazz pianist and researcher of dinosaur culture, as well as texts by science writer Ryuichi Kaneko 金子隆一, were immensely helpful. Although this essay is not exhaustive in its coverage of all events related to dinosaurs, it provides an overview of the history of Japanese dinosaur culture.

The first chapter of this essay focuses on how Japanese people treated fossils before the modern era. It also discusses their reception of palaeontology and the theory of evolution in the 19th and early 20th centuries. The second chapter describes the Japanese public's fascination with Godzilla, ancient relics of the lost world（cryptozoological animals）and dinosaurs during the post-war period. Subsequently, it introduces the emergence of Tokyo Design Kogei's

robotic animals. The third chapter covers the development of robotic dinosaurs and exhibitions, including the Dinosaur Exploratorium, up to 1993.

1. Early Japanese Dinosaur Culture

Japan's First Encounter with Dinosaurs

Contemporary Japanese people are surrounded by dinosaurs. That is, Japanese society continues to be awash in dinosaur books and dinosaur figurines and models made from plastic, paper and wood. Large-scale dinosaur exhibitions are also regularly held at museums. Japanese dinosaur culture dates back to the Meiji period (1868–1912), when the nation enthusiastically imported scientific and technological knowledge from Europe and the United States. However, this does not imply that Japanese interest in fossils began in the 19th century with the arrival of Western knowledge.

According to Bunnosuke Gokan 後閑文之助, Japanese people became interested in fossils through the lens of medicine under the influence of Chinese studies from the Middle Ages. During the Edo period (1603–1868), when Japan enjoyed a period of peace maintained by the shogunate, Japanese scholars began not only to catalogue various fossils but also to discuss their origins. For example, these scholars hypothesised that fossilisation could be caused by the mere passage of time or by being struck by lightning.[2)]

Myths and legends also sometimes influenced theories about fossils. Japanese scholars debated the origin of certain fossils known as 'dragon bones', which had been considered valuable since the Middle Ages. Some Japanese scholars doubted the existence of dragons, a mythical creature popular in Chinese culture, claiming that descriptions of dragons were too varied to constitute a single species. Although 'dragon bones' had features similar to those of elephants, scientists were reluctant to draw any conclusions until the

19th century because their collections were 'contaminated' by fossils of other ancient animals.[3)]

Another well-known episode involves the teeth of *Carcharodon megalodon*, an ancient species of giant shark. Although these teeth clearly resembled the claws, horns and teeth of other animals, their origin remained a mystery. Some scholars claimed they were the claws (or beaks) of the Tengu, a divine being believed to live in the mountain.[4)]

At the end of the 18th century, Japanese people began to be exposed to European literature in the form of retranslations of Chinese translations into Japanese. By the middle of the following century, Japanese scholars were able to periodise ancient times into the Palaeozoic, Mesozoic and Cenozoic eras. Shozan Sakuma 佐久間象山 (1811–1864), an eminent scholar who enthusiastically studied European technologies, walked the mountains and studied fossils from the perspective of modern geology. One of the most important texts that was widely consulted from the end of the Edo period to the beginning of the Meiji period was the Chinese translation of Charles Lyell's *Elements of Geology* (*A Manual of Elementary Geology*). As Gokan pointed out, Japanese people may not have so readily accepted European geology had it not been for the existence of traditional discussions on fossils dating back to the Middle Ages.[5)]

The first Japanese people to encounter three-dimensional models of dinosaurs were the elite members of the Japanese group Iwakura Mission, which was led by Tomomi Iwakura 岩倉具視 (1825–1883).[6)] They toured the United States and Europe to inspect the latest scientific and technological developments and related facilities, including zoos, aquariums and parks. Kunitake Kume 久米邦武 (1839–1931), a member of the mission who published *The Iwakura Embassy* (*米欧回覧実記*, 1871–1873), mentioned Benjamin

Waterhouse Hawkins' dinosaur sculptures at the Crystal Palace, Sydenham and reported that they represented fearsome-looking prehistoric animals.[7)]

The Theory of Evolution and the Idea of Impermanence

The theory of evolution also taught Japanese how to interpret extinct animals. Edward S. Morse (1838–1925), in particular, played an important role in lecturing the theory of evolution to Japanese students. Morse was a zoologist who researched brachiopods and was also interested in the evolutionary relationship between reptiles and birds. He came to Japan in 1877 to study brachiopods and was asked to teach zoology at Tokyo University.[8)]

Japanese zoologist Chiyomatsu Ishikawa 石川千代松 later published a transcription of Morse's lectures (1883). Morse lectured on a variety of topics in science, such as natural selection, sexual selection, the gradual mutation of animals, animal classification, the inheritance of morphological characteristics, the law of use and disuse and the origin of man while repeatedly attacking the Christian view of nature as an 'empty theory'.[9)] He also introduced dinosaurs and *Archaeopteryx*, more specifically, as representing intermediate forms between reptiles and birds.[10)] Furthermore, he emphasised that the law of survival of the fittest could be applied to animal and human life and that in our merciless world, weaker individuals, groups and peoples were easily eradicated by stronger competitors. According to Morse, warlike human races tend to survive because of their ability to organise and plan. He stated, 'When races competed in ancient times, only civilised races survived, while uncivilised races died out. This is natural selection'.[11)]

Morse's lectures were well received by the Japanese public. However, as science historian Masao Watanabe 渡辺正雄 points out, this was not because the Japanese public understood the scientific value of his lecture. The Japanese

audience lacked a grasp of Western scientific knowledge, including morphology, comparative anatomy, geology and palaeontology and were eager to absorb the knowledge and technology of the West; therefore, they accepted the theory of evolution as cutting-edge and, therefore, perceived it as categorically correct. Although the literature of Darwin, Thomas H. Huxley and Friedrich L. A. Weismann was translated into Japanese from the 1870s to the 1890s, Japanese intellectuals were particularly interested in social Darwinism. Indeed, it was the principle of survival of the fittest rather than theories regarding the origin of man that fascinated Japanese intellectuals, who were struggling to transform Japan, as well as its industry and military force, into a powerful nation like the European empires.[12)]

Nevertheless, the fact that Japan did not outright reject the theory of evolution is worthy of further consideration. Watanabe analysed the philosophy of Asajiro Oka 丘浅次郎 (1868–1944), a biologist and thinker who asserted that humanity would one day become extinct, and suggested that Oka—either intentionally or unintentionally—combined the theory of evolution with the Buddhist concept of impermanence. The notion that all individuals and groups, no matter how prosperous, cannot avoid perishing had been a common understanding in pre-modern Japanese society. Indeed, this notion formed the basis of *The Tale of the Heike (平家物語)*, the story of the rise and fall of a great warrior clan (Taira clan) during the Middle Ages. Oka compared the extinction of the dinosaurs to the history of the Taira clan and, ultimately, the fate of humanity.[13)]

Interestingly, palaeontologist Matajiro Yokoyama 横山又次郎 (1860–1942), who played a central role in introducing theories about prehistoric animals to Japanese society before World War II, seems to have held a similar view. In 1911, he wrote,

> We humans are all born as babies and grow gradually over the subsequent months and years until we become hot-blooded adults; then, we become senile and die. Plants and trees are the same. […] So are man-made things. Houses, bridges, railways and other things eventually become useless. Even solid things, like rocks, are broken down into pieces by the rain and turned into sand. This is why Buddha explained the idea of impermanence as meaning that nothing exists forever. […] Now, with the establishment of geology, which studies primeval animals and plants, we are finding increasing evidence for the veracity of the idea of impermanence.[14)]

Five years earlier, in 1895, he had published *The Fossil Textbook* *化石教科書*, a labour-intensive work intended to raise the standard of Japanese palaeontology to that of European countries. In this work, he described ancient mammals, birds, reptiles, amphibians, fish and invertebrates in detail and included many illustrations. He also translated the word 'dinosaur' into Japanese as '*kyoryu*' (*恐龍* or *恐竜*), meaning 'the fearful lizard'.[15)] His book featured well-known dinosaurs, such as *Allosaurus*, *Iguanodon*, *Triceratops*, *Stegosaurus* and *Brontosaurus*.[16)]

Japanese Dinosaur Culture Before and During World War II

Yokoyama preferred to refer to dinosaurs as '*kaiju*' (*怪獣*)—the term applied to the strange and monstrous beasts, such as Godzilla. In particular, he wrote that the stegosaur was 'the weirdest *kaiju*'[17)] or 'the *kaibutsu* [monstrous creature] that would make us tremble the most'.[18)] Writing in 1912 in a magazine for youth, he stated that prehistoric animals were generally bizarre and creepy, especially the 'enormous *kaiju*' allosaur and brontosaur.[19)]

Yokoyama also introduced the Japanese public to Josef Pallenberg's

dinosaur statues at Hagenbeck's Animal Park in Stellingen, Germany. After first describing how the German sculptor restored the dinosaurs, he focused on a scene of two triceratopses facing each other and a battle between a stegosaur and a ceratosaur, commenting that the ceratosaur would devour the stegosaur because 'all herbivores are weaker than carnivores'.[20)]

Yokoyama's knowledge of Pallenberg's work was also important, as he was involved in the early restoration of life-sized dinosaurs in Japan. According to Tamura, a stegosaur and a ceratosaur were erected at the Tokyo Peace Exhibition in 1922 (Figure 2). The ceratosaur was positioned to appear as if it were attacking the left side of the stegosaur's neck and they demonstrated a clear resemblance to Pallenberg's works. These dinosaurs were exhibited by the Kawasaki Factory (I had initially assumed that the three dinosaur statues erected at the Higashiyama Zoo in 1938 were the first figures to be made based on Pallenberg's sculptures).[21)]

My further research revealed that the figures, which were constructed from concrete reinforced with iron, were intended to teach viewers about geological and evolutionary processes. There was also a model showing the strata (i.e. layers of rock and sediment) of the Mesozoic and earlier periods. The model was made from reinforced concrete and decorated with real rocks; it was also accompanied by a plaster figure of *Archaeopteryx* and a painting of the Tertiary period.[22)] Yokoyama supervised the creation of the display.[23)]

Meanwhile, the number of books dealing with dinosaurs also increased in the 19th and early 20th centuries. Tamura identified 15 dinosaur-related books published in the Meiji period, 23 in the Taisho period (1912–1926) and over 40 in the years from 1926 up until World War II. Translated novels by Jules Verne and Arthur Conan Doyle were also included in Tamura's survey.[24)]

Although the dinosaurs appearing in Japanese books may have been

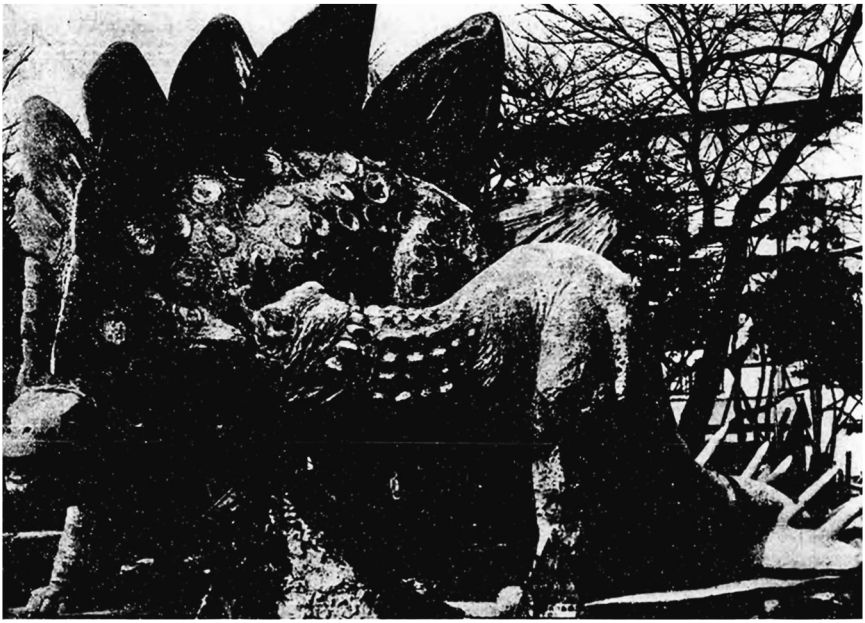

Figure 2. The *Ceratosaurus* and the *Stegosaurus* at the Tokyo Peace Exhibition, 1922 (Ikeda, Takeji 池田竹二, ed. *Tokyo Peace Exhibition Photo Album 平和記念東京博覧会写真帖*. Tokyo: Tokyo Hakurankai Shashincho Hakkosho 東京博覧会写真帖発行所. 1922, n. p.)

entertaining, it was the rampaging dinosaurs that appeared in US films that truly captured the Japanese imagination. The film magazine *The Movie Times キネマ旬報* praised the film *The Lost World* (1925) for its excellent use of stop-motion, the beauty of its cinematography and the thrill and novelty of its story.[25] Even more impressive was *King Kong* (1933). Indeed, one reviewer wrote that 'audiences will certainly be [...] plunged into the unexpected atmosphere of the film, thrilled and with sweaty hands [...]. The great battle scene between Kong and the dinosaur, combined with the sound effects, is an outstanding spectacle'.[26] The scene mentioned in this article is most likely the

scene of King Kong protecting Ann Darrow from a tyrannosaur.

In 1934, a dinosaur fossil was discovered in Sakhalin, which was then part of the Japanese Empire. Palaeontologist Takumi Nagao 長尾巧 concluded that the fossil resembled a hadrosaur and was similar to 'the *kaiju* that fought terribly with King Kong'.[27] The dinosaur was named *Nipponosaurus* and was almost forgotten until it was exhibited in the 1970s.[28] Moreover, in 1938 and 1939, the press reported the fossilised footprint of a *Camptosaurus* from Utah, sent to the National Science Museum in Tokyo, and the theory that 'cold-blooded' dinosaurs had been wiped out by changing climatic conditions.[29]

The image of the dinosaur changed as Japan faced catastrophic defeat after becoming deeply involved in wars with China (1937–1945) and then the United States (1941–1945). A 'space engineer' submitted a brief commentary to the *Yomiuri Shinbun* in 1944, stating that the Japanese must defeat the American B-29 bomber, which he described as a 'modern dinosaur', just as the early humans defeated their ancient counterparts using intelligence and hard work. He wrote, 'We must make a world that forbids the existence of dinosaurs as a reality as soon as possible'.[30]

World War II ended shortly after the explosion of two atomic bombs dropped on Hiroshima and Nagasaki by B-29s. Bombings by the same aircraft also devastated Tokyo and other major cities. Out of the rubble, the post-war dinosaur culture arose, led by a giant monster.

2. Godzilla, the Loch Ness Monster and Robotic Animals

Creating the King of Monsters

Tamura published a collection of dinosaur-related illustrations and toys produced during the Showa period (1926–1989). He demonstrated how illustrations made for children's magazines in the 1960s and 1970s depicted

dinosaurs as grotesque and sluggish. These dinosaurs often stood upright like Godzilla and fought each other; sometimes they were even depicted fighting cryptozoological animals, like the Loch Ness Monster.[31] Indeed, dinosaurs coexisted alongside fabulous monsters and cryptozoological beasts in the chaotic Japanese imagination of the time; this was primarily due to the influence of pre-war writings that described dinosaurs as monstrous *kaiju*.

The film *Godzilla*（*ゴジラ Gojira*, 1955）is particularly noteworthy when discussing post-war dinosaur culture in Japan. In this narrative, Godzilla is a dinosaur that has been surviving on a Pacific island but is forced from his habitat by a nuclear weapons experiment. The beast ends up in Tokyo and wreaks havoc on the city until it is killed by a secret weapon called the Oxygen Destroyer. The story was clearly influenced by the films *The Lost World*, *King Kong* and *The Beast from 20,000 Fathoms*（1953）. In these films, giant animals that have survived since ancient times rampage through major cities. The *Godzilla* film, however, was imbued with the darker atmosphere of World War II and the post-war climate.

According to Hideyuki Inoue 井上英之, who has studied the film's production process, Toho Film Company producer Tomoyuki Tanaka 田中友幸 first suggested a film about a dinosaur that had developed abnormally due to exposure to the radiation of the hydrogen bomb, which, at the time, had caused serious worry among the public. In 1954, radioactive ash from the Bikini Atoll bomb test fell on the fishing boat *Daigo Fukuryu-Maru 第五福竜丸*, sickening the fishermen on board, one of whom later died. This event was linked to the atomic bombings of Hiroshima and Nagasaki and the shocking news in 1953 that the Soviet Union had developed a hydrogen bomb.[32]

Novelist Shigeru Kayama 香山滋 wrote a screenplay based on Tanaka's concept. However, his first script（*G 作品検討用台本*）differed from the final

film. The first difference involved the personalities of the two main characters, Doctor Yamane and Doctor Serizawa. In the film, Yamane, who initially discovers the existence of this Jurassic relic living on a Pacific island, is a quiet scientist. Serizawa, meanwhile, is a serious scientist who regrets having developed the Oxygen Destroyer, a weapon that melts all aquatic life within its range. In Kayama's original script, they are as mad as Godzilla. Yamane, who is preoccupied with his discovery, knocks over two power station workers with an iron pipe to prevent them from pressing the button that will trigger an electric shock that could kill his precious animal. Meanwhile, Serizawa is dissatisfied with the production of the Oxygen Destroyer and is developing a version to be released from the sky that would melt all flesh on land.[33)]

Interestingly, Kayama's script relates that the two scientists have a common background that connects World War II with the post-war period: They had both participated in unearthing fossils in Jehol Province in Manchukuo, the Japanese puppet state. When the war ended, they begrudgingly returned to Japan. Yamane refers to himself as a 'fossil' in the first script, thus drawing parallels between Godzilla's fate and his own.[34)] Museum historian Yasuhiro Inudzuka 犬塚康博 points out that Japanese palaeontologists had actually unearthed dinosaur fossils in Manchukuo and suggests that Yamane may have been modelled after paleontologist Ryuji Endo 遠藤隆次, who had left Manchuria after the war, leaving behind a number of fossils.[35)]

Second, Kayama's Godzilla resembles a tyrannosaur-like dinosaur that devours people and livestock and even shows interest in Yamane's daughter and becomes enraged when she runs away[36)], while the monster in the film shows no interest in consuming flesh. Initially, Kayama and the Toho staff had referenced *King Kong*.[37)] Therefore, I like to think of Godzilla as a cinematic

descendant of Kong's rival, the *Tyrannosaurus*.

However, this *kaiju* is more sluggish and less carnivorous in nature. Due to the compressed production timeline, the producers used a costume instead of stop-motion. Godzilla, who is played by an actor in a costume weighing 60 to 100 kilograms, walks slowly but solemnly through burning Tokyo, his face showing no sign of emotion.[38] This representation of Godzilla contributed to the popular image of dinosaurs, as pointed out by cultural historian Alexis Dworsky, whose book I have often referred to in this series of essays.[39] Kaneko wrote that Japanese dinosaur enthusiasts at the time had to be satisfied with Godzilla and his ilk, as they had no access to real fossils.[40]

Mysterious Animals Haunting Japan

Not only Godzilla was dinosaurs' friend. Turning to the newspapers after World War II, we find an article from 1948 about a dinosaur-like monster 90 feet long and 20 feet high, a relic from 70 million years ago, that had appeared in Assam, India. A photograph of the *Ceratosaurus* restored by the German sculptor Pallenberg accompanied the article.[41]

Another 1964 article reported a reptilian monster haunting Lake Khaiy in Siberia and mentioned similar monsters in Loch Ness in Scotland, Chini Lake in Malaysia and Flathead Lake in the United States.[42] The Loch Ness Monster was, unsurprisingly, the most frequently mentioned: From the 1950s to the 1970s, Japanese readers were entertained by eyewitness accounts, discussions of Nessie's possible existence as a relic of the lost world and scientific research using hydrophones, radar and mini-submarines.[43]

The year 1977 marked a peak of excitement surrounding cryptozoological animals. The public's collective jaw dropped when they saw photographs of a carcass of what appeared to be a 10-metre-long animal with a head 45

centimetres long, a neck 1.5 metres long, fins 1 metre long each and a tail that was 2 metres long. Indeed, this creature, which was caught by the Japanese trawler the *Zuiyo-Maru* 瑞洋丸 off the coast of New Zealand in April 1977, bore a striking resemblance to an ancient marine reptile. After taking photographs, the captain ordered the sailors to throw the carcass overboard for hygienic reasons. However, an employee of a fish company took samples of keratin fibres from its fin to be analysed by experts.[44)]

In July, a group of researchers that included palaeontologist Ikuo Obata 小畠郁生, who would later supervise the Dinosaur Exploratorium, discussed the possible identity of the monster. They concluded that the species could not be identified without more material, although they did not rule out the possibility that it was the carcass of a plesiosaur.[45)]

The Japanese were not only interested in monsters and ancient relics. After World War II, zoos surged in popularity around the world: According to *Zoo and Aquarium History*, more than 280 zoos were established between 1945 and the end of the 1960s, including 65 in Japan.[46)] Tokyo's Ueno Zoo, which experienced a traumatic culling of animal populations during the war, rebuilt its collection and sent a staff member to East Africa from 1951 to 1952 to collect exotic animals.[47)] Indira the elephant arrived in 1949 from India and a giant panda arrived in 1972 from China, similarly attracting the public's attention. This fascination with *kaiju*, mysterious beasts and modern wild animals provided an ideal market for Tokyo Design Kogei to produce robotic animals.

The Birth of Tokyo Design Kogei's Robotic Animals

Tokyo Design Kogei, which was established in 1969, originally produced advertising posters, window displays and shop decorations before it began

designing and producing robotic animals. In 1971, the Keio railway company commissioned Tokyo Design Kogei to create an animal-themed display to promote a new railway line connecting Chofu City and an amusement Park named Yomiuri Land. The staff at Tokyo Design Kogei explored the possibility of making a moving attraction of a seal spinning a ball on its nose that would mimic the actual seal at the park. They observed, sketched, photographed and filmed the seals at Yomiuri Land and Ueno Zoo and studied the existing literature to develop the mechanism, only to be told by their subcontractor that it would be impossible to make because the structure was overly complicated.[48)]

Therefore, the design firm built the display itself and, after two months of trial and error, the company created two robotic seals. Standing 1.67 metres tall and 1.30 metres long and covered in urethane, these mechanical seals were able to spin balls on their noses, successfully attracting passers-by.[49)] Yoshiyuki Sakai 酒井儀幸, president of Tokyo Design Kogei at the time, named these robots '*Dokoku*' (*動刻*), meaning 'moving sculpture' (overseas, they used the English term 'Animobile').[50)]

Tokyo Design Kogei then began releasing a series of other robotic animals. These robotic animals could articulate their front legs, heads, eyes and mouths, and once the company had developed a significant number of robotic animals, it developed a 'Robot Zoo'. This 'zoo' was unveiled at the Science Museum in Tokyo in the summer of 1974 and it featured a seal, monkey, gorilla, lion, tiger, giraffe, polar bear, dinosaur, reindeer, Japanese deer, pandas, kangaroos and penguins. It also included mechanical demonstrations of how the robots worked.[51)] Their exhibition attracted 34,000 visitors, 10,000 more than expected and it was widely covered on television and in major newspapers.[52)]

Based on this exhibition, Tokyo Design Kogei developed a master plan for

future robot zoos at other exhibitors. This plan featured a one-way path and a 'gorilla director' that welcomed visitors. Next, visitors were directed to the northern area (a polar bear and a reindeer), savannah area (a giraffe and lions), Asian area (a tiger and pandas), a section with a chimpanzee stamping cards and an area for performing animals. These areas featured natural landscapes filled with plants and were accompanied by information panels and a reindeer showing its mechanical frame.[53] This plan for the Robot Zoo served as the basis for the dinosaur exhibitions described later.

A major client of Tokyo Design Kogei was department stores. The number of department stores, which stood at approximately 119 at the end of World War II, rose to 364 by 1966 and 477 by 1971.[54] Store managers, eager to outdo their competitors, jumped at the chance to display life-sized robots that could attract people with movements and sound. The Robot Zoo also had advantages over real zoos: They were simple and inexpensive to maintain and there was no concern for visitor safety.[55] Children could also interact with them, touching their front legs and noses.[56]

The first dinosaur produced by the design company was also a crowd-puller. It was a theropod with a horn on its nose and stood upright and roared like Godzilla (Figure 3). Three motors operated its body, neck and mouth movements.[57]

This was soon followed by a *Brontosaurus* and a robotic Nessie (Loch Ness Monster), reflecting the public's interest in such creatures.[58] The Nessie joined The Mysterious and Legendary Animal Exhibition (1975) at Expoland, an amusement park in Osaka. The exhibition featured Hibagon (apes said to live in the mountains of Western Japan), Tsuchinoko (short and stout mythical snakes), a 7.5-metre Nessie, a giant snake and an ape-like Yeti that roared and moved its head, eyes and arms.[59] Mineo Akiyama 秋山岑生, who would later

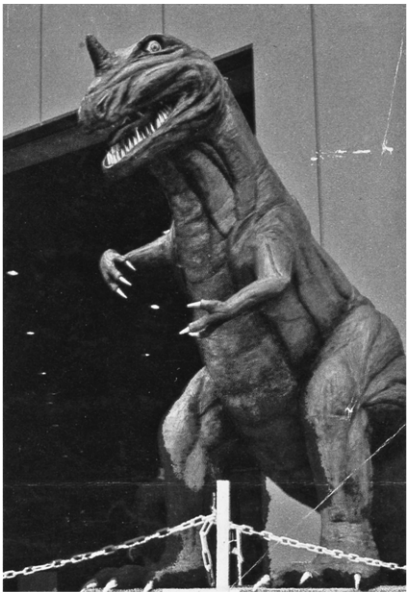

Figure 3. First dinosaur created by Tokyo Design Kogei (©Kokoro Co Ltd.)

serve as president of Kokoro (the successor of Tokyo Design Kogei) from 1986 to 1994, stated that it was difficult to represent these creatures because their true shape and behaviour was unknown.[60] Nevertheless, efforts to recreate these legendary creatures in three dimensions provided them with the experience necessary to create dinosaurs, which, despite being scientifically documented creatures, were similarly ambiguous.

Tokyo Design Kogei also learned how to make its robots look real, even more real than actual animals. When they created their first giraffe, Akiyama and other staff tried to simulate the movements of a giraffe's neck. This was made possible by the use of two joints and a twisting motion. However, to their puzzlement, it seemed to move too fast, despite the neck speed having been

based on studies of real giraffes. When they slowed down the beck speed by half, the robot giraffe appeared more real.[61] They found that simply copying the movements of real animals did not produce a sense of realism.

A *Dokoku News* article noted, 'The most critical factor was to make external expressions and movements natural and smooth, hiding the jerky nature of the machines'. In particular, verisimilitude depended on adjusting 'the timing of the machine control'.[62] When the company created a tiny unicorn for Sanrio, the greeting card company that later founded Kokoro with Tokyo Design Kogei, a motor with a stepless transmission and cranks of various sizes was used, making the unicorn's movements remarkably smooth.[63]

The designs of *Dokoku* were further refined in the 1980s. For example, Tokyo Design Kogei developed the 'Beta System', which used electronic components to analyse and read the 4,800 pulses emitted every second by the magnetic tape used to generate the movements.[64] They also developed an air servo system that allowed air cylinders within the characters to stop precisely at any desired position. Although hydraulic pressure was more suitable for this purpose, the designers preferred air pressure because it was simple and inexpensive to maintain; there was also no risk of oil leaks.[65] When I interviewed Kayako Kido, who now works in the sales division of Kokoro, she stated that durability and ease of maintenance were the most important features of her company's products. For these reasons, air pressure was ideal. With advances in technology, computers began to control the movement of the figures and the CAD/CAM system came to assist in planning and design.[66]

Realistic appearances were also essential for *Dokoku*. On one occasion, an old lady asked a railway station attendant to bring down the 'poor giraffe' on display at a high place near the ceiling of the station, thinking it was real.[67] Even a staff member at Tokyo's Tama Zoological Park mistook Tokyo Design

Kogei's motionless orangutan as an actual stuffed orangutan and criticised the decision to taxidermy such an endangered animal.[68] Although the fur, fangs, claws and even irises of the figures looked real, they were completely artificial.[69]

The next chapter discusses how, amidst the rise of Japanese dinosaur culture, the design techniques learned during the creation of the internal and external components of these robotic animals were applied to the creation of robotic dinosaurs.

3. The Maturing of Japanese Dinosaur Culture and Robots of Prehistoric Animals

Great Fossil Exhibitions

The process of dinosaurs being differentiated from *kaiju* and other cryptozoological animals progressed slowly but steadily as dinosaur fossils became increasingly accessible to the public. The first complete dinosaur skeleton to arrive in Japan came from the United States. Yukichi Ogawa 小川勇吉, who ran a hotel in Los Angeles, donated an 8-metre-long allosaur unearthed in Utah to the National Science Museum in Tokyo. The allosaur was put on public display in 1964.[70]

Moreover, in the early 1970s, Japanese department stores also organised exhibitions of dinosaur skeletons. Such displays included a plesiosaur *Futabasaurus* discovered in Japan in 1968, a hadrosaur *Nipponosaurus* discovered in Sakhalin before World War II and dinosaur fossils from the United States, Brazil, Madagascar and France.[71] More impressive was the Soviet Dinosaur Exhibition (1973) at the National Science Museum, which included a mounted *Tarbosaurus* (a member of the *Tyrannosaurus* family), *Protoceratops* and *Saurolophus*.[72] Subsequently, waves of dinosaurs from

Eastern bloc countries arrived in Japan: approximately 250 fossils from the Soviet Union（1978）, 372 fossils from China（1981）and more than 370 fossils from East Germany（1984）. These exhibitions covered a wide range of animal species, including fish, amphibians, mammalian reptiles, marine and flying reptiles, dinosaurs from all periods, ancient mammals, early humans（*Ramapithecus* from Yunnan Province, China）and plants.[73)]

They also included fossils of significant national value. While the Soviet Union repeatedly exhibited *Tarbosaurus* and other dinosaurs, China displayed whole skeletons of the sauropod *Mamenchisaurus* and the stegosaur-like *Toujiangosaurus*. Humboldt University in East Germany loaned its impressive fossil skeletons of a *Brachiosaurus* and the *Archaeopteryx* to the National Science Museum for what was claimed to be the world's largest exhibition.[74)] These major exhibitions were followed by subsequent exhibitions of dinosaurs from the United States（1984, 1986）and the Belgian *Iguanodon*（1985）,[75)] demonstrating that dinosaurs had left the realm of *kaiju* and had come to occupy a secure place within the Japanese popular imagination by the late 1980s.

Doraemon, one of the most popular comic series in Japan created by manga artist Fujio F. Fujiko 藤子・F・不二雄, illustrates this point. Fujiko has created several short stories and two longer stories featuring dinosaurs since the beginning of the 1970s. One of these short stories, titled 'Dinosaurs, Please Come to Japan'（恐竜さん 日本へどうぞ, 1981）, features a boy protagonist named Nobita who travels back to the Jurassic period with the help of the robot Doraemon to invite Chinese dinosaurs to what would become Japan; the story was clearly inspired by the Chinese dinosaur exhibition.[76)] Fujiko also vividly depicted the prehistoric fauna and flora in his long stories *Nobita's Dinosaur* のび太の恐竜（1979）and *Nobita and the Knight of the Dragon* のび太

と竜の騎士 (1986–1987).[77] These stories were adapted into films in 1980 and 1987, respectively.

Nemesis

During these years, there was also intense interest in the question of why the dinosaurs went extinct. Dinosaurs were often assumed to be sluggish like Godzilla and cold-blooded and, therefore, unable to survive changes occurring on Earth. A 1957 *Yomiuri Shinbun* article on the history of Earth described dinosaurs as 'giant reptiles too spoiled by the warm and tranquil climate of the Mesozoic era'. In contrast, the small ancestors of mammals were said to have undergone 'cold-resistant training'[78] on the barren wastelands where they lived, which had made them more adaptable—an unforgiving interpretation of the struggle for existence. This image of dinosaurs was also adapted as a metaphor for modern developments. An article in the *Mainichi Shinbun* (1971) described the coal and film industries of the time and the automobile industry of the future as 'dinosaurs' because of their 'simplistic behaviours, inability to adapt to change, lack of ideas and stupidity regarding their fate'.[79] Dinosaurs were also likened to the Soviet Union struggling to maintain its vast size and a baseball team unable to forget its past glory.[80] These metaphorical uses of dinosaurs in Japanese culture conform with Dworsky's observation that dinosaurs have often been compared to anachronistic and outdated things within the logic of social Darwinism and capitalism.[81]

Of course, Mesozoic giants did not die out because they were spoiled or stupid. Rather, a dramatic, even catastrophic, event likely caused their inevitable extinction. However, the Japanese public's interest was often piqued by reference to extraterrestrial causes, such as the radiation from an exploding star,[82] Earth's entry into a molecular cloud[83] or an asteroid crash. The interest

of the Japanese public peaked when the translation of Richard A. Muller's *Nemesis* appeared in 1987. In this book, Muller discusses the asteroid theory of Luis W. Alvarez and Walter Alvarez, as well as his own theory. The two Alvarezes, who were father and son, famously concluded that an 8-kilometre asteroid had crashed to Earth 65 million years ago—an assertion that was based on the presence of large quantities of iridium, which is rarely found on Earth, in the Cretaceous–Paleogene boundary. Meanwhile, Muller speculated that a companion star to the Sun, Nemesis, causes a shower of comets to hit Earth every 26 million years when it enters the Oort Cloud that surrounds the Sun.[84] The supervisor of the translation of *Nemesis* was Osamu Tezuka 手塚治虫, a well-known manga artist.

As Dworsky points out, it is not surprising that the theory that the dinosaurs were killed off by an astral body became particularly popular in the post-war era. The destructive force that wiped out the dinosaurs is reminiscent of the power of nuclear weapons, which could destroy the entire human race if used on a large-scale. Additionally, the dramatic changes to the climate that would follow an asteroid impact, such as the cooling of Earth due to smothering dust, stirred images of the 'nuclear winter' that would follow a nuclear war.[85]

Although Dworsky's observations can be applied to Japan, I must add some elaboration to this discussion. In 1987, a bookseller interviewed by *Yomiuri Shinbun* stated that the widespread interest in the extinction of the dinosaurs was consistent with the pervasive sentiment that the world was coming to an end. The bookseller also said, 'A prophecy said that Earth would end at the end of this century'.[86] The prophecy alluded to here was that of French astrologer Nostradamus（Michel de Nostredame, 1503–1566）, or, more accurately, a Japanese interpretation of his prophecy. In 1973, novelist Ben Goto 五島勉 published an interpretation of Nostradamus' prophecy, asserting

that the world would end in 1999.[87)]

Some might laugh at such claims. Nevertheless, there was something about this prophecy that appealed to the Japanese public. In the 1970s and 1980s, the Japanese economy sustained growth led by the automobile and electronics industries.[88)] However, the public harboured an underlying fear that Japan's success would not last forever and could be halted by a sudden catastrophe. The global pollution problem and political turmoil between the Western and Eastern camps provided a justification for this fear,[89)] a fear that came to be represented by falling asteroids and comet showers that could obliterate Japan along with all other nations.

Exhibitions Featuring Dinosaur Robots

As dinosaurs came to secure a prominent place in Japanese culture, Tokyo Design Kogei developed a concept for a robotic dinosaur exhibition. In 1978, they announced an idea of the 'Science Museum of Evolution'. Working with palaeontologists and archaeologists, it would display prehistoric amphibians, reptiles and mammals in naturalistic panoramas.[90)] The plan came to fruition at the aforementioned Soviet dinosaur exhibition in 1978, when the design firm's robotic dinosaurs were shown alongside fossils from the Soviet Union.

They increased the number of robotic dinosaurs and innovated the exhibit design as the Soviet exhibition toured through Japan. When it was held in Osaka, there were six robotic animals, then seven in Nagoya (Middle Japan), 12 in Kitakyushu (Western Japan) and 16 in Saitama. In the beginning, the dinosaurs were not displayed chronologically according to their appearance in history. In Kitakyushu, for example, the Permian sailfin reptiles *Edaphosaurus* and *Dimetrodon* were displayed first, followed by ancient mammals, such as the mammoth, woolly rhinoceros and sabre-toothed tiger. *Tyrannosaurus*,

Stegosaurus, *Brontosaurus*, *Triceratops* and *Pachycephalosaurus* were in the main area with the *Diatryma* bird and *Platybelodon* (extinct proboscidean). Nevertheless, 'The atmosphere was like jumping through a time tunnel from modern times into the primeval world'.[91)]

The moving dinosaurs were accompanied by weather and lighting effects: When the exhibition was held at the UNESCO Village in Saitama, powdery snow and thunderous lightning contributed to the impressive and frightening aura of the exhibition.[92)] For the exhibition in Niigata (northern Japan), Tokyo Design Kogei built a large double-layer tent to block out sunlight and enhance the lighting effect. The lighting changed continuously, representing morning, afternoon, dusk and night. The chronology of the exhibition was also corrected: Cenozoic animals came first, followed by Mesozoic and Paleozoic animals.[93)]

In 1984, Tokyo Design Kogei decided to merge with Sanrio Company, for whom they had already developed the robot unicorn, to form a new company called Kokoro. Sanrio's president, Shintaro Tsuji 辻信太郎, wanted to combine his company's characters, which included Hello Kitty and friends, with Tokyo Design Kogei's technology.[94)]

The new company continued to exhibit its robotic dinosaurs. Instead of describing all of Kokoro's exhibitions, I would like to highlight significant exhibitions in terms of design. The summer dinosaur exhibition (1987), held successively at department stores Shinjuku Mitsukoshi 新宿三越 and Fujisawa Saikaya 藤沢さいか屋, was remarkable because it also featured ancient marine reptiles. A large *Futabasaurus* (plesiosaur), *Mosasaurus* and ammonites swam in underwater dioramas. There was also a *Tyrannosaurus* confronting a *Chasmosaurus*, a *Corythosaurus* watching its hatchlings and two *Pachycephalosaurus* butting their heads.[95)] These dinosaurs reappeared in another exhibition (1988) at the amusement park Nagashima Spaland. It was a

large-scale indoor space where visitors travelled along a one-way path while gazing at enormous herbivorous and carnivorous dinosaurs, flying and marine reptiles, ancient mammals and cave dwellers displayed amidst three-dimensional dioramas of volcanos, plants, rocks and ice.[96] This impressive exhibit (Figure 4) is reminiscent of Disney's Magic Skyway at the New York World's Fair (1964–1965) and *Jurassic Park*, which had yet to be released at the time.

Reflecting the growing public interest in the extinction of the dinosaurs, Kokoro added a new 'experience theatre' to its department store dinosaur exhibition (1988). While robotic animals represented the period from the emergence of amphibians to the heyday of the dinosaurs, the theatre allowed

Figure 4. The Great Dinosaur Exhibition in Motion at Nagashima Spaland, 1988 (©Kokoro Co Ltd.)

visitors to experience the shower of comets that wiped dinosaurs from the face of Earth, a representation that was based on Muller's theory. The sales copy read, 'Did the dinosaurs see Nemesis?'[97]

New Theories, New Robotic Dinosaurs

Although the image of the sluggish, tail-dragging dinosaur remained dominant throughout the 1970s and 1980s in Japan, newspapers occasionally introduced new dinosaur theories from abroad. The *Yomiuri Shinbun*, for example, provided details of Robert T. Bakker's interpretation of the brontosaur in 1971, calling it 'a shocking new theory'. Based on the shape of the brontosaur's skull, teeth, neck, tail and legs, as well as the strata in which it was found, Bakker asserted that the brontosaur was a terrestrial rather than semi-aquatic dinosaur.[98] Likewise, the possibility that dinosaurs were warm-blooded was raised in Japanese newspapers in the 1970s and 1980s.[99]

As Ryuichi Kaneko recalls, when Adrian J. Desmond's *The Hot-Blooded Dinosaurs* was translated into Japanese in 1976, it had a massive impact on Japanese dinosaur enthusiasts. It not only introduced the theory of the hot-blooded dinosaur but also emphasised that theropods walked with their bodies stretched horizontally and their tails raised off the ground. It also suggested that some dinosaurs were intelligent and agile, that sauropods lived on land rather than in lakes, that many dinosaurs lived in groups and that birds were descended from dinosaurs. These claims were based on the latest research by such eminent scientists as Bakker, John H. Ostrom and Barny Newman.[100] Kaneko wrote,

> Dinosaurs as smart as mammals? That's amazing! So what about all those old-fashioned dinosaurs that look like lizard bosses? Why do all the

dinosaurs reconstructed in paintings walk awkwardly with their tails dragging and their legs bent? We can say that the divergence between the commercial image of dinosaurs and the image of dinosaurs held by dinosaur enthusiasts has entered a decisive phase.[101)]

Judging from photographs in *Dokoku News*, it appears that Kokoro continued to exhibit old-fashioned-looking dinosaurs with tails that dragged behind them until the late 1980s. A photograph of an *Iguanodon* with its tail raised appears in an article from 1985; this appears to have been the model displayed at the Belgian *Iguanodon* exhibition at the National Science Museum.[102)] The obvious change began in 1987 when Kokoro started producing a new series of dinosaurs.[103)]

Interestingly, the debut of this new series coincided with the publication of Bakker's beautifully illustrated *The Dinosaur Heresies* (1986). His revolutionary theory about warm-blooded, active dinosaurs, which was based on insightful research on their skulls and other bones, their attacking and defending tools, cartilage, organs and muscles, as well as their relationships with each other and plants, was discussed extensively in this book.[104)] The Japanese version was published three years later.

Dinosaur Science 最新恐竜論 (1989) also summarised the latest scientific discoveries in the field, introducing the works of both Bakker and John R. Horner.[105)] Horner, another star palaeontologist, made a now well-known discovery of a nest of eggs belonging to the duck-billed dinosaur *Maiasaura* (1979). Juvenile skeletons, eggshells and a nest-like structure were excavated at the Two Medicine Formation in Montana. Horner and Robert Makela wrote, 'The fact that 15 baby hadrosaurs had been feeding, and had stayed together for a period of time, indicates that some form of extended paternal care was

administered for, if the young were confined to the nest, food must have been brought to them'.[106)]

The *Maiasaura* exhibition（1990）at the National Science Museum focused on this discovery. Under Horner's supervision, Kokoro mainly planned, designed and installed the exhibits, which included Maiasaura robots, their nest and a 6-metre-long moving diorama of the migrating Maiasaura herd.[107)]

Kokoro's new dinosaur series also coincided with the company's overseas expansion. As the educational value of *Dokoku* became recognised internationally, museums in Los Angeles, Jacksonville, Las Vegas, Miami and Berkeley chose to display *Dokoku* of prehistoric animals, including tyrannosaurs, triceratops, brontosaurs, sabre-tooth tigers and mammoths, around 1985.[108)] Kokoro set up an office in Los Angeles in 1987 to supply robotic animals to these markets directly,[109)] and by the end of the 1980s, it was exporting its dinosaurs to Thailand, Taiwan, Australia, Singapore and England. Since 1990, the Natural History Museum in London has acted as an agent for Kokoro's robotic animals, supplying them to other European museums.[110)]

The Dinosaurs Exploratorium

Meanwhile, Kokoro's robotic dinosaur exhibition continues to evolve. The Dinosaur Spectacle（1990）at Tamakawa Takashimaya 玉川高島屋 was designed as an 'ecological exhibition', reconstructing the life of dinosaurs in an uninterrupted space by featuring additional displays of a pack of *Deinonychus* attacking a *Tenontosaurus*, a *Protoceratops* couple nursing their eggs, a Triceratops family and a *Tyrannosaurus* facing a *Chasmosaurus*.[111)]

The Moving Oceanic Dinosaurs Exhibition（1991）at the department stores Fujisawa Saikaya and Saikaya Yokosuka さいか屋横須賀 was remarkable for its exclusive focus on ancient marine animals. Visitors pass

through a cloud of bubbles to enter a prehistoric sea inhabited by a coelacanth, *Elasmosaurus* (Figure 5), *Ichthyosaurus* and *Archelon,* an ancient turtle. After being 'devoured' by a big-mouthed monster, visitors witness a battle between a giant squid and a *Nothosaurus* before being threatened by a *Mosasaurus* and a *Paranothosaurus*. A giant *Dunkleosteus*, an armoured fish with sharp teeth, swims gracefully among some small fish in the Devonian Sea at the exit.[112] Department store exhibitions also taught the Kokoro staff how to use limited space effectively. For example, in a summer exhibition in 1992, giant dinosaur body parts, rather than complete dinosaur bodies, were on display: Visitors walked under the belly of an *Apatosaurus* and between its moving legs before encountering a *Tyrannosaurus* with its head poking out of a bush. Other

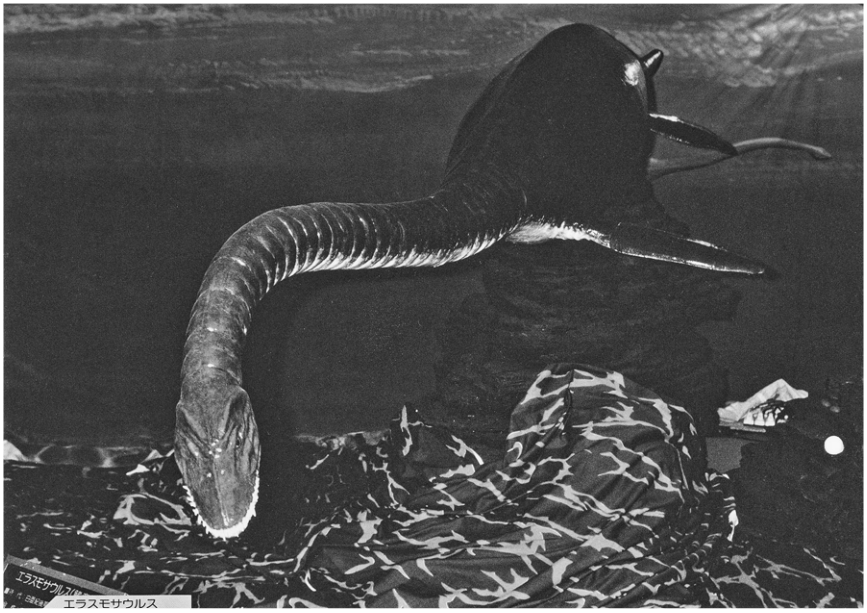

Figure 5. The *Elasmosaurus* at the Moving Oceanic Dinosaurs Exhibition, 1991 (©Kokoro Co Ltd.)

missing body parts were cleverly concealed by plants.[113)]

The year 1993 marks a pivotal milestone for Japanese dinosaur culture; Stephen Spielberg's *Jurassic Park* was released that summer. It featured a T-Rex chasing a jeep with incredible speed, velociraptors cunningly hunting humans and brachiosaurs walking gracefully on the ground—all scenes that shocked moviegoers to the core and finally obliterated the image of dinosaurs as sluggish.

There were also around 20 major dinosaur events in Japan that year, with fossils and robots on display. Many of these events seem to have attempted to capitalise on the film's popularity.[114)] One of the most popular was Dino-Park (10 July–31 August, Tokyo), which featured robotic dinosaurs, such as *Tyrannosaurus*, *Triceratops*, *Velociraptor*, *Brachiosaurus* and *Dilophosaurus*, constructed by the US company Dinamation International. Dinamation was founded in 1986 and produced robotic animals, with scientists George L. Callison and Bakker serving as advisers for the company.[115)]

Another large exhibition was Dino Alive (17 July–23 November, Osaka). Its main feature was a tyrannosaur roaring atop a trampled triceratops. I saw this exhibit as a 13-year-old, and it made me shudder in true fear. Indeed, the filming techniques used made the exhibit particularly scary. Christopher J. Walas created the dinosaur at the request of the model maker company Kaiyodo 海洋堂. Walas, the special effects artist who also created works for *Piranha* (1978) and *Gremlins* (1984), made the tyrannosaur larger than existing fossils. It was 15 metres long, making it much more imposing to onlookers. It also moved smoothly using hydraulic pressure and roared directly through a loudspeaker in its mouth—a roar that blew one's soul away.[116)]

Moreover, 1993 was also the year that Kokoro's Dinosaur Exploratorium opened—the culmination of over 20 years of development. Unlike the

exhibitions mentioned above, the Dinosaur Exploratorium was meant to be permanent, and planning for the project began when Seibu Railway Company decided to renovate the UNESCO Village. The village, consisting of 41 ethnic exhibition spaces, was originally built by the railway company to commemorate Japan's acceptance into UNESCO in 1951. Faced with a drop in visitor numbers from 700,000 to 400,000, the railway wanted to revamp the village with a new dinosaur building, with Horner overseeing the displays.[117)]

Five years of preparation went into the museum. Staff collected material in the United States, studied individual plant species and the characteristics of each animal and analysed the body structures of lizards, crocodiles and birds. They also consulted scientists Horner, Obata and Yukimitsu Tomida 冨田幸光 while showing them small-scale dioramas. They first made 1:20-scale dinosaurs and then constructed life-size versions. They then transported the finished dinosaurs to the museum and checked their movements.[118)]

This process of producing robotic dinosaurs and animals constituted something close to a true craft. According to a 1993 interview with Ikuhisa Takahashi 高橋育久—who developed the robots' movement mechanisms and later became president of the company (1999–2006)—the technique for cutting the urethane foam that covers the metal skeleton is of crucial importance. The staff repeatedly moved skeletons in small increments to confirm which part of the foam needed to be cut or adhered to the machines. They also rubbed many colours, at least ten, into the special rubber used to make the skins. Takahashi stated, 'They must have a deep colour that does not look like it is painted but rather like it is seeping out from within'.[119)] Additionally, dinosaur sounds were created by adjusting animal sounds.

Akiyama explained in another interview that all the dinosaur's movements were generated by injecting air or oil into cylinders within each body part of

the dinosaur. The cylinders were connected to pipes with valves that were opened and closed by computers to adjust the compressed air or oil. Akiyama stated, 'Computers make [dinosaurs] appear alive by combining many movements'.[120] As a result, dinosaurs could inflate their bellies, make a gulping action with their throats and blink their eyes. Meanwhile, motors moved their bodies back and forth.

Kokoro News stated the following about the Dinosaur Exploratorium:

> The Exploratorium is the first and largest science museum where visitors can explore the ancient world through powerfully moving life-sized animals, primarily dinosaurs, that were created based on the latest theories about how life evolved, from the origin of life to when the dinosaurs became extinct. Kokoro was responsible for the planning, the construction of the 250 dinosaurs and the creation of all the display elements including the creation of the environment, which was based on historical research, as well as the art, lighting, sound, film and so on. The Exploratorium is the culmination of the long development of *Dokoku* technology, which has reached a high level of perfection.[121]

The building was made of reinforced concrete, covered 8,500 square metres, cost about 100 million yen and included a 381-metre long, 60-centimetre deep channel that took visitors on a 13-minute adventure. The exhibition covered the period from 400 million to 65 million years ago and featured sculptures of 650 animals belonging to 40 species, 250 of which could move.[122]

The exhibition was divided into seven zones: The Era of Early Life and Fish (Zone 1); the Herd of Amphibians and Reptiles (Zone 2); the Valley of

Rhamphorhynchus (Zone 3); the Era of Giant Dinosaurs (Zone 4), where visitors floated under the belly of an *Apatosaurus*; the Night Sea (Zone 5), which featured *Elasmosaurus* and *Pteranodon*; the Nursing *Maiasaura* (Zone 6); and the Battle of the Dinosaurs (Zone 7), which featured battles between a *Deinonychus* pack and *Tenontosaurus* and between a *Tyrannosaurus* and *Triceratops*.[123] The entrance fee was 1,200 yen for adults and 600 yen for children and during the first winter holiday season, visitors had to wait three hours to enter the Exploratorium.[124]

As this design shows, Kokoro combined all of its displays at department stores and amusement parks. Moreover, I want to emphasise that the Dinosaur Exploratorium was remarkable not simply because of the moving robotic animals. It is important to recognise the allure of the combination of their movements with the exquisite detail of their scales, fins, irises, wrinkly skin, teeth and claws. The exhibits were also unique for the artificial plants and rocks of different types and sizes, which were created based on in-depth research. The weather effects of blue skies, dark nights, beautiful sunsets and thunderstorms made the dinosaurs seem either peaceful or fearful, depending on how these elements were deployed. Even if the creatures were immobile, the museum could still tell the vivid story of life on Earth—that is, the story of environmental change that Yokoyama told during the pre-war period through texts, illustrations and sculptures.

Conclusion

The emergence and evolution of Japanese dinosaur culture have been heavily shaped by foreign influences. First Chinese and then European and American scientific knowledge provided Japanese people with successive frameworks for interpreting fossils. The lost world of the dinosaurs, which has

been depicted in texts, illustrations, sculptures and films, resonated with the Buddhist concept of impermanence, and dinosaurs have continued to fascinate Japanese people throughout the 20th century. Although initially confused with *kaiju* and cryptozoological animals, dinosaurs have occupied a firm place in the Japanese imagination since the period when a growing number of fossils from the United States, the Soviet Union, China and Europe began to be exhibited. Meanwhile, interest in extant wildlife species also grew, and Tokyo Design Kogei was able to capitalise on this trend. Robotic animals, which were safe, inexpensive and easy to maintain, attracted orders from clients such as amusement parks, department stores and museums, first from Japan and later overseas.

As newspaper articles, books and the development of Kokoro's Dinosaurs demonstrate, the image of warm-blooded dinosaurs with straightened tails gradually entered the public consciousness in the 1970s and 1980s. However, it was the 1993 film *Jurassic Park* that finally did away with the old-fashioned image of slow-moving dinosaurs. Kokoro had already exhibited moving dinosaurs based on Bakker and Horner's research and after five years of preparation, Kokoro was able to open the Dinosaur Exploratorium in the year of the film's release. Although this amazing attraction has been closed since 2006, Kokoro continues to create dinosaur robots that fascinate dinosaur enthusiasts who grew up watching *Jurassic Park*, *Jurassic World* and *Godzilla*.

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