URBAN PALEONTOLOGY

Evolution of Urban Forms

Ming Tang, Dihua Yang

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For our parents.

CONTENTS

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INTRODUCTION

More than ten years ago, when I first read Mario Gandelsonas' book *The Urban Context*, the beautiful abstract diagrams that the book presented—the street network of Chicago—fascinated me with the profound historical and cultural background that they suggested. Without knowing how this would direct me, I started to draw something related with the street network of Beijing. That is the beginning of this book. Among tons of the diagrams that I have created, most of them have not been incorporated into this book, while they have directed me into this fascinating research area which focuses on the "mineralized skeleton," rather than the "soft tissue" of urban forms.

It was not until the recent five years when Yang and I came across some theories and approaches in paleontology that we started to integrate them into the street network study in Beijing and Savannah. Paleontology methods lay the foundation and provide a systematic and scientific platform for our research. Then urban paleontology, as a new framework for urban form study, unfolds itself more and more apparently in front of us. It explores the evolution of "urban species" based on their remains—"urban fossils," which describe distinct urban forms with imprints of their street networks. Just as how a biological fossil serves as a factual documentation of certain life forms, an urban fossil provides clues of the existence and transformation of urban forms.

The study of urban paleontology inevitably directs us to further exploration in the fields of biology, anatomy, archeology, geology, and the application of computer aided design in the excavation of urban sites. Upon finishing this book, we realize that our work is too inadequate to possibly incorporate all the influence that other disciplines may have on architecture and urban design. What it has suggested is that architecture presents such a wide array of connections with other disciplines and becomes more and more towards an interdisciplinary study. We hope this book has illustrated the diversity of problems that invite further study and can serve as a start point for architects to conceive the total spectrum.

Ming Tang

CHAPTER ONE 1

FROM PALEONTOLOGY TO URBAN PALEONTOLOGY

"Male or female, king or queen, no one can be sure. But of one thing there is no question: Sue rules! … It stands 13 feet high at the hips and 42 feet long from head to tail. … Its species was well-adapted to its environment. … As it grew, its bones underwent changes: some wore down, others fused together, still others developed bony calluses. …It died near a fast-moving river … its body was quickly covered by riverbed sand and mud. Over time, pressure and some remineralization turned its bones to fossils. … Its skeleton provided a key piece of the puzzle that links dinosaurs and birds—a wishbone…"

—The Field Museum, Chicago[1]

"Around the Xiannong Temple there was a continuous wall of ten meters high that formed its boundary. The inside fabric featured well-landscaped open spaces…Established in 1420, it has been one of the dominating urban forms for about five-hundred years. However, changes were occurring gradually on its street network. …Wide orthogonal streets with circular islands at the intersections were introduced, and multi-story apartments were constructed in the open spaces. …This ancient temple has eventually developed into an individual of a new urban species—Filled-in Block. …The evolution of Xiannong Temple illustrates how a new urban species is derived from an individual of the existing urban species through accumulated changes across urban strata."

—Chapter II

1.1 PALEONTOLOGY VS. URBAN PALEONTOLOGY

Paleontology is the study of life forms on Earth through the examination of biological fossils. In this book, the coined term "urban paleontology" refers to the study of urban forms through the analysis of "urban fossils," which is defined as the remains of urban forms during the evolution history of urban environment.

The origin of paleontology dates back to ancient Greek time. However, it was not until the establishment of evolutionary theory in the late nineteenth century that paleontology reclaimed its popularity in academic communities and became as a major player in various interdisciplinary studies of biology and geology ever since. One of its major contributions to life form studies is its support of evolution theories by providing evidence for evolution trees traced with fossil records. Taking the discoveries and descriptions of dinosaur fossils as an example, the evolution tree shown in Fig. 1-1 illustrates a major group of dinosaurs and their evolutionary relationships based on evidences revealed by fossil studies. On this evolution tree, each branching point is a node, indicating a new feature in the common ancestor of the group found on branches originating at that node. For instance, the node shared by all dinosaurs features a hole in the hip socket, which indicates that dinosaurs possessed a different hip structure from their reptilian relatives. The node of relatively long-armed Coelurosaurs includes the "bird-mimic" ornithomimids, whose general body proportions are very reminiscent of birds' proportions (Fig. 1-2). This group of dinosaurs is part of a larger and more complicated evolution tree—the Tree of Life[2].

In urban paleontology, a similar concept as the evolution tree is also applied in city development studies. Although often portrayed as a gigantic manmade object, a city behaves very much like an organism with great vitality that grows over time. The emergence and extinction of urban forms is a natural phenomenon as much as the succession of biological species. Therefore, the term "urban species" is introduced to classify urban forms into distinctive groups. Each urban species refers to a group of urban forms with certain shared characteristics inherited from their recent common ancestors. The evolution history of such urban species reflects the context of their urban habitat in a way very similar to how biological species reflect their eco-habitat. In addition, urban species are imprinted with traces of social, historical, cultural, as well as technological transformations in the city, which add multi-dimensions to urban paleontology studies.

Urban paleontology is a branch of urban morphology, where paleontological approaches are employed to study the evolution of urban forms. Its major function is to identify and reconstruct urban species, both "survived" and "extinct," and to explore the evolutionary relationships among them. Understanding where urban forms came from and how they have changed is the key to predict how they will evolve in the future. With such knowledge, we will be able to understand our cities better and guide their development accordingly.

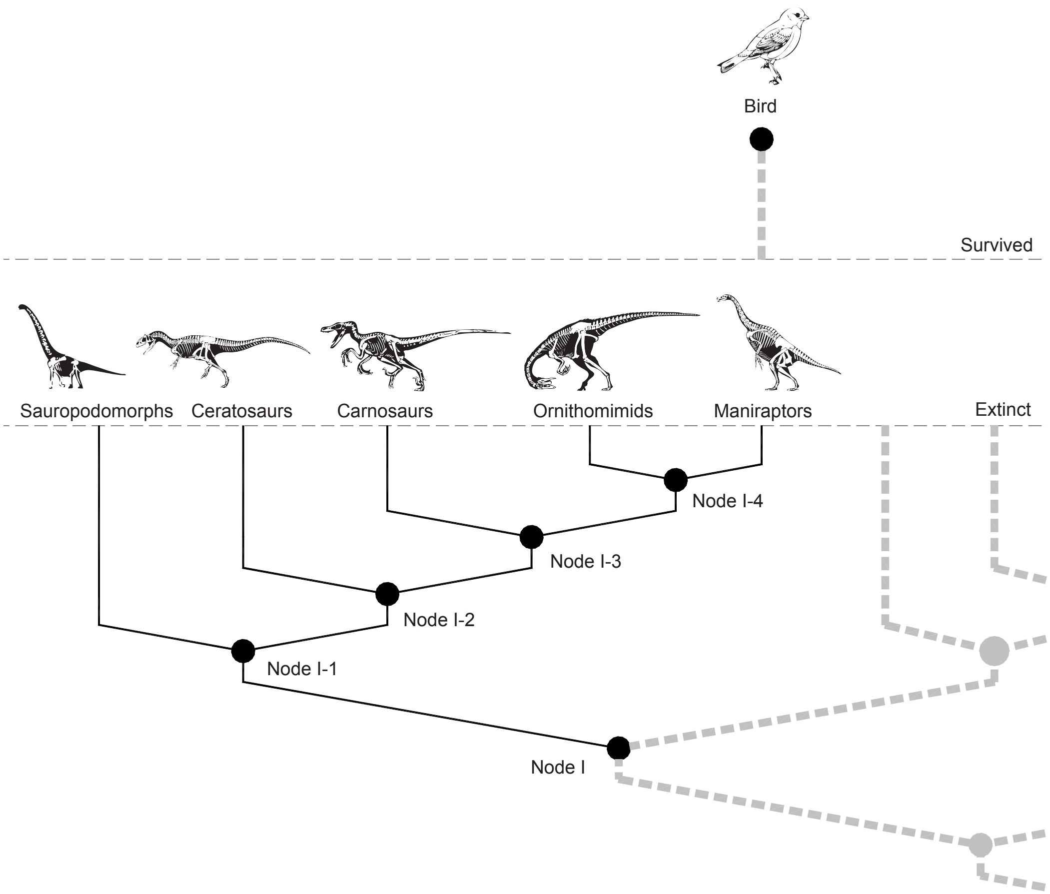
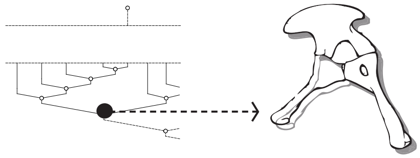


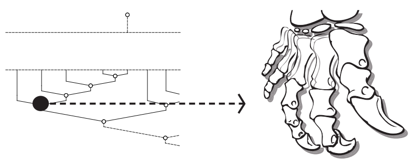
Fig. 1-1. A group on the evolution tree of dinosaurs.

• NODE I: ALL DINOSAURS:



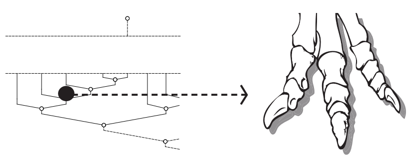
The node for all dinosaurs indicates that "dinosaurs possessed a different hip structure than their other reptilian relatives. The hip socket had a hole in the middle of it, and a strongly developed rim of bone formed the upper margin of the socket." [3] Since the force generated by supporting the body was directed toward the upper margin instead of the center of the hip socket, no bone was need in the center. A hole in the hip structure has been an evolutionary advantage. The result was a more erect posture of dinosaurs.

• NODE I-1: GRASPING HAND SAURISCHIANS:



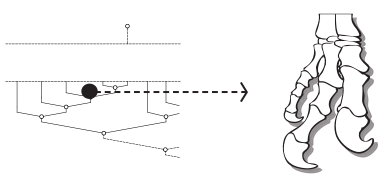
The node of the "grasping hand saurischians" explains the evolutionary success of saurischian dinosaurs from the structure of their hand. "The fingers are of different lengths, and the thumb is somehow offset from other fingers. This results in an arrangement that appears to have allowed most saurischians to have at least a limited capability for grasping." [3] The wings of living birds today are in reality evolved from this grasping hand.

• NODE I-2:THREE-TOED FOOT THEROPODS:



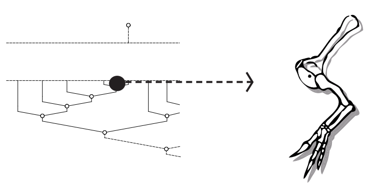
The node of "three-toed foot theropods" presents "an advanced feature of theropod dinosaurs." "The central toe is larger, while the outside toes are reduced or lost. This arrangement is the same as that found in birds." [3]

• NODE I-3: THREE-FINGERED HAND TETANURANS:



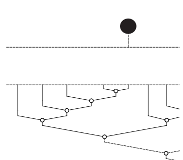
"Three-fingered hand tetanurans" is developed from the five-finger grasping hand. This advanced feature allows even greater grasping ability.

• NODE I-4: RELATIVELY LONG-ARMS COELUROSAURS:



"Relatively long-arms coelurosaurs" is the node that "includes the 'bird-mimic' ornithomimids as well as maniraptors such as velociraptor and birds. Coelurosaurs have relatively long arms, which may have been used to capture prey and have been evolutionarily modified into wings for flight in birds." [3]

• NODE OF BIRDS:



Over the last two decades, evolutionary research has claimed that birds evolved from some small carnivorous dinosaur. Overwhelming skeletal similarities between the first known bird, *Archaeopteryx*, and small dinosaurs have strongly supported this statement.

Fig. 1-2. Nodes on the evolution tree of dinosaurs.

1.2 BIOLOGICAL SPECIES VS. URBAN SPECIES

1.2.1 DEFINITIONS

A well-accepted definition of the biological term “species” was formulated by Ernst Walter Mayr as “an array of populations which are actually or potentially interbreeding and which are reproductively isolated from other such arrays under natural conditions.”[4] When two individuals of the same species breed, their genes pass into their combined offspring and give that individual its identity. Therefore, species remain distinct, and individuals of the same species share characteristics from their common ancestor.

In urban paleontology, an “urban species” is defined as a group of urban forms that can be reproduced through similar interbreeding process and whose reproduction remains distinct from other groups of urban forms. Individuals of the same urban species share the same characteristics and bear the same generic imprints from their recent common ancestors. Such genes in urban paleontology take various forms and carry different strengths in the reproduction, among which the characteristic of street network has significant impact in the evolution of urban forms. Therefore, this book is concentrated on the study of street networks and their influence in urban fabric and urban space.

1.2.2 HOMOLOGOUS STRUCTURES

In comparative anatomy, “homologous structures” are “the same structure in different animals, despite the fact that they are not only dissimilar in appearance, but they also have different functions.” [5] An example of such structures is shown in Fig. 1-3, where the man’s limb and the whale’s limb have different functions and are superficially different, but their internal skeletal structures are essentially the same.

In urban paleontology, the word “homologous” is borrowed from comparative anatomy to describe structures in different urban species that appear differently but are actually derived from a common ancestor. Such homologous structures prevail throughout the history of urban development, especially when the function requirements changes much more dramatically than the forms themselves. Fig. 1-4 illustrates an example of such homologous structures in urban paleontology, where the park and the mixed-use area show different appearances and functions, but both of them are derived from ceremonial temples in the early time of urban development history.

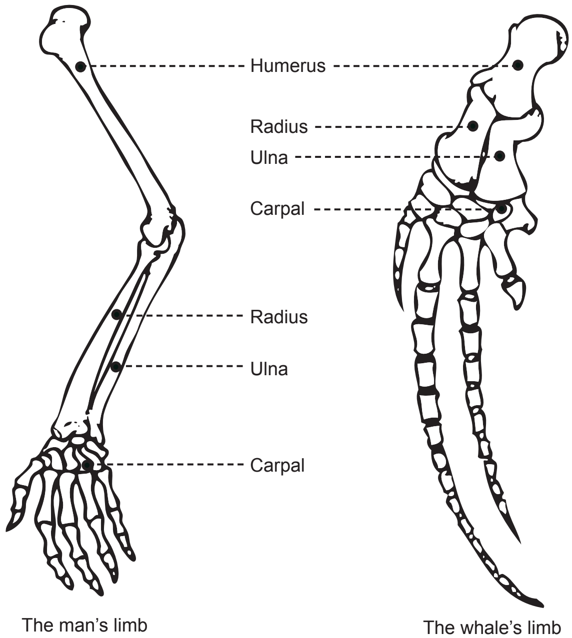


Fig. 1-3. Homologous structures in comparative anatomy.
The man's limb and the whale's limb have different functions and are superficially different, but their internal skeletal structures are essentially the same.

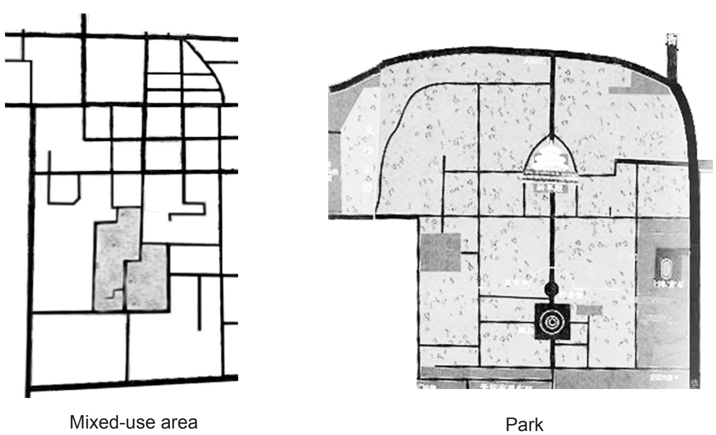


Fig. 1-4. Homologous structures in urban paleontology.
The park and the mixed-use area show different appearances and functions, but both of them are derived from ceremonial temples in the early time of urban development history.

1.2.3 ANALOGOUS STRUCTURES

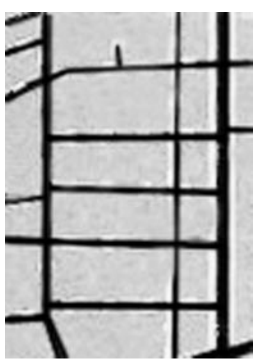
In contrast, structures sharing the same appearance but are yet different organs are described as “analogous structures”[6] in comparative anatomy. Here, similarities are acquired through the adaptation to common functions or environment requirements. A convenient example of analogous structures is the wings of bats and the wings of moths, where organs coming from different embryological origins are built for the same function of flight (Fig. 1-5). In-depth anatomy studies are often required to uncover the true origins beneath the seemingly homologous structures. In the above example, skeleton study proves bat wings are derived from the forelimbs of ancient mammals, while the moth wings arose as novel outgrowths of the body wall rather than directly related to any pre-existing limbs.

In urban paleontology, “analogous structures” are also difficult to identify. Because rather than being the evidence of the shared gene from a common ancestor, similar appearances become the major deception of the structures’ origins. Fig. 1-6 illustrates the comparison between two mixed-use areas in the city, both of which present similar street network, function, and appearance. However, one is derived from a military camp, while the other is developed from a historical residential neighborhood.

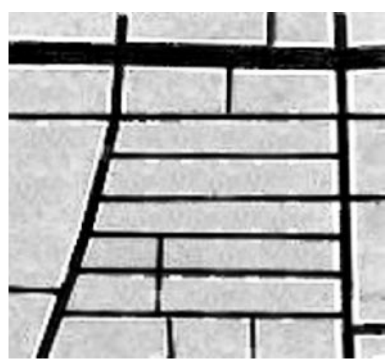
Bat wings:
The origin of bat wings is clearly revealed by their skeleton, every element of which is homologous with structures in the forelimbs of other mammals. Bat wings evolved as a result of modifications to the forelimbs of their ancestors.

Moth wings:
The moth wings arose as novel outgrowths of the body wall, not directly related to any pre-existing limbs.

Fig. 1-5. Analogous structures in comparative anatomy.
The wings of bats and the wings of moths have different embryological origins but are built for the same function of flight.



Mixed-use area derived from a military camp.



Mixed-use area derived from a historical residential neighborhood.

Fig. 1-6. Analogous structures in urban paleontology.
Both of the two mixed-use areas present similar street network, function, and appearance. However, one is derived from a military camp, while the other is developed from a historical residential neighborhood.