Living Form in Mammalian Biology

Excerpts from *Understanding Mammals: Threefoldness and Diversity*

Wolfgang Schad

My purpose is to place in the absolute center of inquiry the direct perception of the animals most closely related to us — the mammals — as they live in their natural environment. We shall approach them with the confidence that their lives openly and plainly convey what is essential for our understanding of them. As we recognize the unique quality of each animal form, it poses a much neglected question whose answer, like the meaningful word of an as yet uncomprehended language, can be supplied only by the living form of the animal itself.…

We know a great deal about genetic factors, basic physiological processes, predictable instinctive reactions, and the social behavior of animals. But no one can tell us why well-known hoofed mammals, like cattle, deer, and rhinoceroses, have head protuberances, while horses, donkeys, tapirs, and camels do not. Neither molecular biology nor behavioral research concerns itself with the significance of an animal's form. One view regards it as a collection of randomly acquired adaptations, while the other sees it as the result of responses to external stimuli. But we will never rid ourselves of the suspicion that a living organism's form expresses more than what is conveyed by such conventional interpretations. An animal, especially a vertebrate, is visible material substance, living form, and animated, sentient life. How are these different aspects related to each other, and how can we comprehend this relationship by observing the animal itself ? Such are the questions that always arise whenever we observe animals. [p. 2]

When we observe the human form, we immediately see that it is organized into the trunk, the head, and the limbs. The head raises itself quite distinctly above the rest of the body, while the limbs are closely connected with the trunk. Rudolf Steiner differentiated our human physical organization, however, not only in terms of its visible parts, but also according to its functional processes. Thus he grouped the processes in the abdominal region together with those in the limbs, characterizing them as a common system that constitutes a polarity with the processes in the head. Mediating in both form and function between these polarities is the chest with its organs. How do its form and function reveal their mediating role? A closer look at the polarities of the organism will provide a context for grappling with this question.

The head rests upon the body. It has little mobility within itself and is mostly solidified in the rigid bony structure of the skull. In contrast with the rest of the body, it moves but little. Above the runner's flailing limbs and panting chest, the head quietly keeps the goal in view. Most of the sense organs — those of sight, hearing, balance, smell, and taste — are gathered in the head. Through these senses the organism opens itself fully to the surrounding environment. Connected as it is with the sense organs, the nervous system, too, has its center in the head. The brain is the organ through which the organism gains the capacity to orientate itself and find its way in its environment. Thus the head is the center of what we may call the *nerve–sense system*, through which the organism perceives and adjusts itself to the requirements of the surrounding world.

In contrast to the head, the limbs and the organs of the abdominal cavity engage in strong bodily activity that is expressed both in actual physical movement and in the intense chemical activity of the metabolism. The organs of the abdominal cavity process food, which at first is alien to the body, through such dynamic chemical processes that it is transformed into the body's own substance. Thus the main function of the metabolic organs is to maintain the organism's physiological autonomy vis-à-vis the environment. The abdominal cavity, the body's largest, is also the least protected by bones; any hardenings in the soft organs it encloses (e.g., gall stones, kidney stones, and bladder stones) are a sign of disease. This fact stands in contrast to conditions in the head, where, for example, crystalloid formations within the pineal gland of the brain (brain sand) are considered normal and non-pathological.

Though the skeleton is expressed more strongly in the structure of the limbs, the placement of the limb skeleton is obviously polar opposite to that of the cranial bones. While the latter form a "shell" directly beneath the skin and serve as an external skeleton that protects the soft organs within, this relationship is reversed in the limbs. Here, arm and leg bones form the internal skeleton that is surrounded by the softer tissues. It is noteworthy that while nearly all the head bones have fused to form a single rigid structure, the limbs

HERE WE OFFER READERS of *In Context* a glimpse into a book that is the fruit of Wolfgang Schad's many decades of research into the dynamic morphology of mammals. I've met many people whose eyes were opened by Schad's work to a fundamentally new and exciting way of understanding the forms and characteristics of mammals. This was also the case for me. Moreover, he has inspired other researchers and helped them discover patterns in different groups of animals.

The first German edition of *Säugetier und Mensch* was published in 1971, when Schad was thirty-six years old. An English translation, entitled *Man and Mammals*, was published in 1977. For many years the book has been out of print and eagerly sought after as a rare used book. But Schad never stopped researching, and his ability to hold innumerable facts and then weave them into a meaningful and coherent picture is truly remarkable. In 2012, the new German edition was published — two volumes totaling 1300 pages! Truly, a lifetime achievement.

Now, through the tireless efforts of publisher John Barnes and editor Mark Riegner, we have an English translation that includes new material (Schad remains an indefatigable researcher at eighty-three!) and many new illustrations. In the scope of its treatment of mammals and in the uniqueness of approach, the book is bound to become a classic.

Animal form is usually interpreted through a Darwinian (or better said, Neo-Darwinian) view of evolution. All characteristics, whether the color or patterning of the fur or the form of the teeth, are considered in terms of survival. How do the long neck of the giraffe, the flat tail of the beaver, the larger molars of a horse, or the horns of an antelope allow the animal to survive? The beaver's teeth are good for gnawing wood, the large flat tail for swimming and as a paddle to slap against the water to alert other beavers about the presence of potential predators, and the high-set eye sockets for swimming inconspicuously with its head only slightly above the water surface. In a way, all these "explanations" make sense. But they are also quite speculative. Moreover, this way of looking leads us to mentally dissect the animal into different traits, each of which has its own type of survival value. The coherence and integrity of an animal dissolves into a collection of traits, and all its characteristics are considered solely as adaptations that secure survival.

Already long before Darwin, Goethe protested against trying to explain animal traits in terms of their utilitarian functions. He wrote, "We conceive of the individual animal as a small world, existing for its own sake, by its own means. Every creature is its own reason to be … We will not claim that a bull has been given horns so that he can butt; instead, we will try to discover how he might have developed the horns he uses for butting."* This means that we need to study the characteristics of an animal in relation to one another and see if we can discover how they fit together with the context of the animal as a whole.

In this spirit, Wolfgang Schad studies animals. From childhood onward, Schad was a keen observer of animals. When he later studied Rudolf Steiner's idea of threefoldness in the human being — of which you'll find a brief sketch in the accompanying excerpt — he formed a mental lens that allowed him to see patterns in animals that had hardly been recognized before. With this lens he has been able to build up a comprehensive picture of the diversity of mammals.

A threefold pattern in mammals is perhaps most vividly displayed in the differences between rodents, carnivores, and hoofed mammals (ungulates), which the excerpt focuses on. Of course, there are many other groups of mammals and Schad shows how the lens of threefoldness can help make sense of some of this variety. Moreover, one can see recurring themes within the different groups that otherwise remain unappreciated.

Schad is not interested in fitting the diversity of mammals into a rigid and neat system. Rather, he explores what kinds of relations the lens of threefoldness allows one to see. And many notable and surprising connections show themselves in the 1300 pages of the two volumes. Few readers will study the entire book page by page. But once you work enough with the book to gain a good sense of what Schad means by threefoldness, you can begin to see and appreciate the nuanced iterations in different groups. You begin to move in a world of dynamic connections. Then you can select individual chapters about, say, bats or whales, and not only learn interesting details about these animals, but also have your eyes opened to connections you would have never noticed on your own.

This book belongs in every good library. It will help animal lovers and educators gain a new way of looking at the diversity of mammals. *CH*

* Goethe, J. W. von. 1995. *Scientific Writings.* Princeton, New Jersey, Princeton University Press, p. 121. Goethe wrote the quoted text in 1795; it was first published in 1820.

are equipped with many joints, and their bones branch out into the multiplicity of the fingers and toes. These allow for the organism's independent mobility in its environment. This *metabolic–limb system* also includes the reproductive organs.

Between the relatively immobile nerve–sense system and the highly active metabolic–limb system, we find the organs of the chest region. Lungs and heart are rhythmically pulsating organs. In each, contraction and expansion, tension and relaxation, compression and dissolution alternate constantly. The polarities of the organism, therefore, are always present in this region; but here they do not maintain their spatial separateness; rather, they actively complement one another through their rhythmical alternation in *time*. Thus we can speak of the *respiratory–circulatory system* or the *rhythmic system*, or simply the *middle system*. [pp. 15-16]

The human organ systems are also found in all mammals. Among the mammals, however, the three main systems relate to one another in very different ways in that one or another system is especially well developed. Thus, high degrees of specialization have been attained so that, in accordance with the views of comparative morphology, we may consider many of these animals to be evolutionarily and thus physically more highly developed than the human being. In this sense, as already mentioned in Chapter 1, the rodents, carnivores, and ungulates [hoofed mammals], in particular, rank above the insectivores, primates in general, and humans. The great morphological diversity (i.e., disparity) among rodents, carnivores, and ungulates seems to defy any attempt to find guiding principles that would lead to an ordering of this extraordinary multiplicity. Yet the equally great morphological and anatomical diversity *within each organism* may itself supply the key to finding order among them all. In fact, it will be our best guide as we learn to see the extraordinary diversity of mammalian forms as a manifestation of their inherent unity.

Taking the threefold human being as our starting point, we find that the mammals demonstrate what remarkable differences are possible in the relationships among the three main organ systems. The dairy cow, with its mighty digestive processes and its prominent hoofed limbs, brings these organic systems into strong relief. Its whole organization is determined by the special qualities of the metabolic–limb system, and this emphasis is characteristic of all ungulates. Mice, in their nervous sensitivity, show the greatest possible contrast to the bovine nature. Their extremely refined sense organs so dominate the other organ systems that we may characterize the mice and all other rodents as primarily nerve–sense animals. It is more difficult to generalize about the carnivores, such as cats, dogs, and seals, but I hope to demonstrate that these animals live primarily out of the processes of respiration and blood circulation.

Photo: E. A. Janes

Figure 1. A wood mouse (*Apodemus sylvaticus*), which belongs to the long-tailed mice.

Rodents	Carnivores	Ungulates
Sense–nerve functions predominate	Rhythmic functions predominate	Metabolic–limb functions predominate

What is brought to near perfection in the one-sided developments of the mammals yields in the human being to a delicate balance that is seen in the mammals only when they are taken together and considered within their respective environments. Only in an undisturbed landscape, when in biological equilibrium with one another and with other animals and plants, do the mammals show the balanced relationship that appears in the human body as an integrated whole.

The anatomy of the hoofed mammals shows a considerable hypertrophy of the limbs. In contrast with the five-digit type of limbs of the less specialized mammals, the ungulates' feet have regressed to a few bones, which, however, are very strongly formed. This specialization of the limbs extends even to the powerful enlargement of the nail into a hoof, which gives the group its name (i.e., ungulate). The limbs of horses and cattle support massive bodies and, in stamping and galloping, horses express the powerful animating forces within them.

Figure 2. A mountain lion (*Puma concolor*).

Figure 3. The African, or Cape, buffalo bull (*Syncerus caffer*).

The limbs of rodents are the polar opposite. Tiny and delicate, they hardly deviate from the original five-fingered form. Their fingers and toes are narrow and long, with nails shaped like tiny claws. The forepaws of squirrels, for example, are adept at grasping, handling, and feeling. Their limbs have clearly acquired a sensory function. Long sensory facial hairs (whiskers), and shorter ones over the entire surface of their body including their bushy tail, project beyond their warm coat and enable squirrels, fitfully twitching and hopping, to find their way in the surrounding world. In many rodents even the inside of the cheek in the mouth cavity is covered with sensitive hairs. Agile and quick in its reactions, a rodent lives in constant agitation, alarmed pauses, and rapid flight. Even in sleep, nervous spasms periodically run over its small body.

Rodents must sleep often. In all animals it is always the nerve–sense system that in the waking state so exhausts physiological functioning that this can be restored only in the unconsciousness of sleep. The organs of nutrition, which function outside consciousness, are indeed never awake, and it is for this very reason that they are able to continue functioning day and night. Thus rodents in particular, because they are so active in their senses, require frequent periods of rest even during the day, when they sleep for short intervals in order to be wakeful again.

Hoofed animals, in contrast, require little deep sleep. One or two hours, sometimes less, suffice for horses, cows, elephants, and giraffes. In these metabolic animals the processes that build up the body predominate even during the waking state, so that these animals tire much less readily than do the rodents. Contented peace and restfulness suffuse the cow's placid gaze, especially when, ruminating for hours, she devotes herself entirely to her food. Her eyes, and the eyes of all ruminants, lack the yellow spot, the *macula lutea*, which is the part of the retina with clearest sight. To the ruminants, the outside world appears diffuse. They have a stronger experience of smell and taste, senses more connected with the inner working of the metabolism than the eyes and ears. A cow is never as completely awake as a mouse; the unconscious processes of digestion predominate even in the ruminant's state of half-wakefulness.

The digestive tract of ungulates is highly developed, especially in their most characteristic group, the ruminants. A large, four-chambered stomach completely fills the anterior abdominal cavity. The intestines are extremely long: 22 times the length of the body, or about 60 m (200 ft) in cows. The principal nutritive substance of the grass, herbs, leaves, straw, and twigs eaten by the ungulates is cellulose, a food rather poor in nourishment, and extremely difficult to digest. It is thoroughly chewed twice, mixed with saliva, and fermented. Only with the help of symbiotic microorganisms that flourish in the gut, specifically the rumen, do the ruminants manage to assimilate a food so difficult to digest, and to build from it such extraordinarily powerful and large bodies. Cows can be fed nothing but straw for a period of weeks if given enough water and some urea as a source of nitrogen, resorbing the latter in their kidneys and using it to create more complex proteins. They even have a surplus of nourishing substances left over for others to utilize. From time immemorial, the ruminants have been able to serve

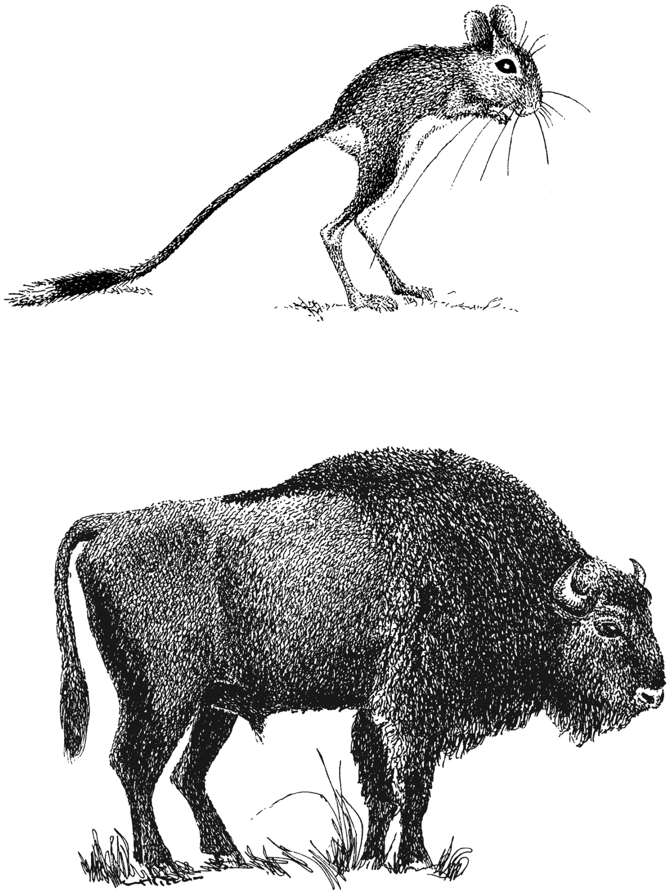

Figure 4. The lesser Egyptian jerboa (*Jaculus jaculus*) emphasizes the posterior pole as strongly as the European bison (*Bison bonasus*) emphasizes the anterior pole. (Drawings: U. Winkler)

as a source of nourishment for humans: cows, goats, sheep, reindeer, and camels have supplied milk since prehistoric times. Even their dung deserves mention as an especially valuable fertilizer for plants.

Typical rodents prefer nourishing foods high in energy. They especially like the concentrated fats and oils of nuts and seeds, as well as kernels rich in starch. They have less taste for fruits, and they will accept plant material composed chiefly of cellulose only when nothing else is available. Among the extremely sensitive rodents, the physiological capacity of the metabolism is so weak that it requires only easily digestible, energy-rich foods, substances that meet the metabolism halfway and readily support it. Such highly nutritive substances are vigorously and hastily extracted from the contents of the intestines; consequently, the desiccated, impoverished droppings that remain are composed of hard, tiny pellets that provide almost no nutrients for plants.

While the ungulates' food consists mainly of cellulose, and most rodents prefer food especially high in energy, carnivores consume the protein found in the meat and blood of their prey. This food, of course, also requires a powerful digestion, but it is much closer to the carnivores' own bodily substance than the cellulose that nourishes the ungulates. We thus arrive at the following overview of the three groups (the important role of exceptions will be discussed later):

Rodents	Carnivores	Ungulates
Nourishing food rich in energy: Fats, Oils, Starch	Foods similar to the body: Protein	Foods difficult to digest: Cellulose

There is an inverse relationship between the quality of the food ingested and the bodily size and substance of the animal eating it: in mice, rich, nourishing food is taken up by a body that contains almost no fat deposits for use as energy reserves. The opposite is true of the ungulates: they take in relatively poor food and yet develop from it substantial fatty deposits that are stored in subcutaneous tissue (producing ham in pigs), around the mesocolon, around the kidney (producing beef suet in cattle), and in humps (e.g., in camels). In diverse environments around the world, ungulates gather the substances taken from plants and, through their physiological processes, unconsciously work to enrich the energy these substances contain. While nervous constitutions characteristically break down substances, metabolic ones rebuild and augment them. The nutritive processes of the carnivores represent an intermediate state. When a leopard devours a gazelle, a true change of substance does of course take place during digestion, but the change from one form of protein to another hardly alters the chemical energy level.

The formation of the teeth is highly significant for understanding the morphology of mammals. Let us first consider our own human mouth. The most touch-sensitive part is its opening in the front: the surface of the lips and the tip of the tongue. Here, food is touched and examined, then bitten off with the incisors. (The incisors are particularly sensitive to the dentist's drill!) Next, it is thoroughly chewed and its taste fully enjoyed. The processes that follow become less and less conscious and controllable. The chewed and ensalivated food is moved back to the region of the posterior tongue and the soft palate, and the involuntary act of swallowing passes it down into the unconscious part of the physical organism. Thus the three parts of the oral cavity are arranged as follows: in the anterior part, the conscious nerve–sense pole is predominant; in the rhythmic chewing and tasting, the middle system prevails; in the unconscious throat area, the metabolic system predominates.

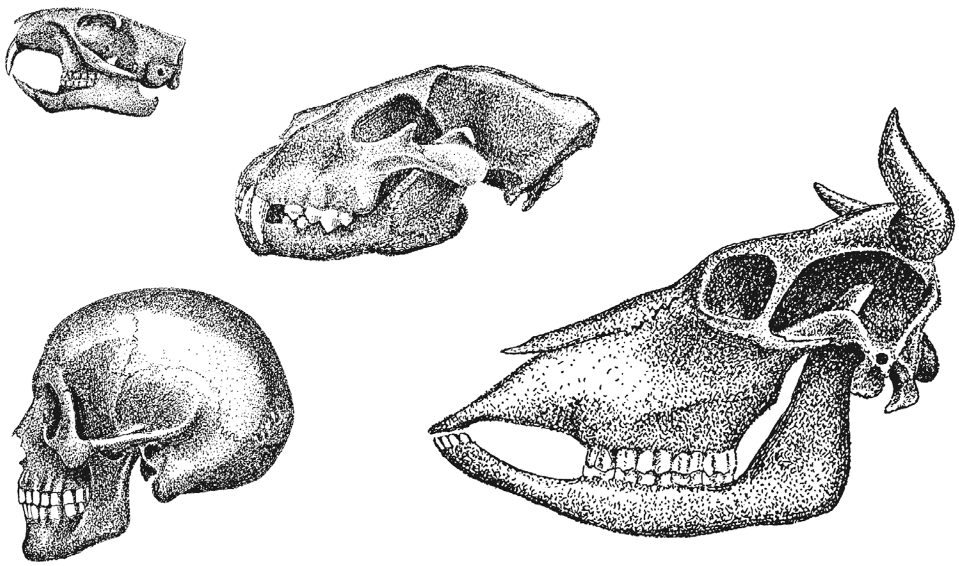

Figure 5. Dentition and skull formation of a rodent, carnivore, and ungulate, in comparison with the human skull. (Drawing: U. Winkler)

This threefold structure is expressed visually in the formation of the teeth. The incisors of humans are anterior and slender, with narrow cutting edges; the molars in the posterior are broad, with wide crowns and slightly curved grinding surfaces. In position and shape, the canines, with their rounded yet pointed (i.e., conical) structure, take their place between the other two.

The following arrangement shows the basic tripartite structure of the teeth. During development, there are two dentitions. First, the milk teeth emerge; in humans there are 2 incisors, 1 canine, and 2 molars in both sides of each jaw, making a total of 20 teeth. At the time of the second dentition, the roots are dissolved and the crowns shed. The permanent set of teeth adds 3 molars in each section of the mouth in addition to the 20 teeth that are replaced, so that the adult comes to have 20 + (4 x 3) = 32 teeth. Because of their position, the replaced posterior teeth are called premolars and the newly formed ones, molars. Molars and premolars are very similar in shape.

Kipp (1952) thoroughly studied the threefold aspect of mammalian teeth. The primarily sense-oriented rodents show a highly specialized development of the anterior incisors; they have two long gnawing teeth shaped like chisels in both the upper and lower jaws. Canines are absent. We find very few molars in typical rodents (e.g., mice, rats, hamsters), and these are indeed "molars" because they have no precursors in that milk teeth do not appear in rodents.

Incisors	Canines	Molars and Premolars
Sense-nerve oriented	Dominated by the middle systems of rhythmic processes	Metabolic-limb oriented
Rodents	**Carnivores**	**Ungulates**
Incisors accentuated	Canines accentuated	Molars accentuated

In carnivores the canines dominate and are often many times as long as the other teeth! The incisors are rather small, and those next to the canines are often even shaped like them, as in the African lion and the leopard seal. The molars, with their pointed crowns, also take on some of the characteristics of the canines; the largest of them is called the carnassial or "shearing" tooth. In most seals, the molars are pointed like canines.

In ungulates, in contrast, the molars are particularly well developed. With their very diverse, complicated formations of cusps and crescents, these teeth are both large and numerous in the posterior oral cavities of horses, rhinoceroses, pigs, hippos, camels, giraffes, deer, sheep, and cattle. The teeth of the ruminants are especially characteristic; in these, the processes of the nerve–sense and rhythmic systems are so completely dominated by the forces of digestion that the cow's upper jaw has no incisors or canines at all! The incisors and canines of the lower jaw form a broad, shovel-like plate that cannot be used for biting, but only for tearing. The molars predominate. Thus the characteristic forms of mammalian dentition become understandable.

It is significant that all rodents and most ungulates lack canines, the intermediate tooth form. Between the incisors and molars of these animal groups is a large gap (diastema) that is usually much wider than the space fully developed canines would occupy.

Naturally, the jaw's principal direction of motion in eating is vertical — a coming together of the upper and lower teeth. Yet, in the rodents, the jaws also move forward and backward, while in the ungulates (especially the ruminants) they move more laterally. Among the carnivores this motion is entirely vertical. [pp. 37-42]

Another important phenomenon in the biology of form is the size that a living organism attains. Every plant and animal species occupies a more or less characteristic amount of space. Although its final height remains quite variable, an oak grows to a size that is different from that of a bean plant. The size of any adult animal, especially among the more highly developed ones, is relatively fixed. Does the size of an animal have a lawful relationship to its other special characteristics? Goethe touched upon this point in his osteological studies (1795):

> At this point an observation must be made that is significant for natural history in general. The question arises: Does size influence shape and form, and to what extent? ... At first sight we might assume that it should be equally possible for a lion as for an elephant to attain a length of twenty feet.… Experience shows us, however, that a fully developed mammal does not exceed a certain size, and that, when size increases, form starts to disintegrate and monsters develop.

In ordinary experience, we unconsciously take for granted that the natural size of each organism is subject to some kind of rule. To this end, I list the following representatives of the three main groups:

Table 3.1.

Representatives of the three main groups of mammals:

Rodents	Carnivores	Ungulates
Mice	Wild cats	Cattle
Rats	Lynxes	Bison
Dormice	Foxes	Deer
Squirrels	Wolves	Moose
Ground squirrels	Seals	Horses

We notice at once that each group tends to have a common size. Ungulates usually develop large bodies; rodents, extremely small ones. Once again the carnivores occupy the middle position, as do humans. For the individual structure and function of an animal, its size is apparently not a matter of indifference — it is distinctly relevant to its way of life. Strongly sense-oriented animals take up only a small space, those dominated by the metabolic-limb system fill out large forms, and representatives of the rhythmic middle system typically occupy an intermediate position in their relationship to space. Obviously, an organism's spatial dimension is of biological importance.

With our context established, it is now necessary to go beyond the general threefold classification of rodents, carnivores, and ungulates to examine the more specific animal forms of single families, genera, and species. Readers can decide for themselves whether or not the idea of threefold structure and function can shine light on the particular features of these organisms. [pp. 44-45]

The above excerpts from Chapters 1, 2, and 3 of Understanding Mammals: Threefoldness and Diversity *by Wolfgang Schad (Ghent, New York: Adonis Press, 2018) were compiled by Craig Holdrege to provide an introductory overview to this new and important book. The excerpts are published here with the kind permission of Adonis Press.*