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No Evidence for Bone Evolution

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Abstract

The evidence for bone evolution from some nonbone substance was reviewed, concluding that all of the bone evolution proposals have been falsified. In the words of one researcher, bone magically appeared in life and left no trace of its evolution, even though bone and teeth are one of the materials that have the best record of preservation of all biomaterial in the fossil record. Bone is one of the most complex organs in the body and, if it evolved, there would be clear evidence of its evolution. The evolution theories proposed to explain bone evolution were also examined in some detail, showing they were all very problematic.

Introduction

The evolution of body organs (such as the lungs, heart and liver) is problematic because, except for the inside of some dinosaur bones, soft tissues are very rarely preserved in the fossil record. Due to a lack of fossil evidence, the primary details of organ evolution can be studied only by comparing a wide variety of living animals, and then by assuming modern animal examples represent their ancient ancestors. This is less of a problem in studying the evolution of bones because bones and teeth are, by far, the best-preserved materials in the fossil record, and millions of well-preserved examples exist in museums and private collections. All past attempts to explain bone evolution, such as the aspidin theory, have been rejected, in this case by synchrotron tomography, leaving no plausible theory of bone evolution from some simpler tissue (Keating, et al., 2018, pp. 1501–1506).

The origin of bone is a critical event in evolution because it is "the key innovation underpinning the evolution of the vertebrate skeleton," and thus of the evolution of all higher-level vertebrates (Keating, et al., 2018, p. 1501). Bone was also considered one of the most important steps in evolution because, if it did not occur, birds, reptiles, mammals, amphibians, or primates would not exist (Switek, 2019, p. 32). The bone skeleton is called "the fantastic framework" by Professor Goldbert, adding that bone was built with the strength of an oak, yet

> can bend with a sapling's ease. It shelters the organs, supports the body and, bound by muscle, bestows the grace of movement. A relic that long outlives the flesh, bone nonetheless meets the moment's needs. Ever building and breaking down, this dynamic tissue forms in proportion to the task at hand. The bones of a ballerina's feet, a sculptor's hands or a bricklayer's arms gain mass and shape in response to the stresses their varied pursuits impose (Goldbert, 1986, p. 7).

This poetic description does not begin to describe the wonder of bone that produces the skeleton supporting life.

Skeletal Tissue Types

Four skeletal tissue types exist (bone, teeth enamel, dentine, and cartilage), all which preserve well in the fossil

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record. Yet, the fossil record provides no evidence for the evolution of any of these tissues. Because their origin is unconstrained by the fossil record, speculation substitutes for data and, consequently, speculation abounds, creating controversy (Wagner and Aspenberg, 2011, p. 393). Furthermore, even though, "primitive fossilized vertebral skeletons are scarce and … their remains often contain tissues that are difficult to classify," this finding has not stopped speculation, especially that which is contrary to what little evidence exists (Wagner and Aspenberg, 2011).

Connective Tissue

The major structural components of the vertebrate body are bone, muscle, and cartilage. Cartilage is a critical connective tissue widely employed in both vertebrates and invertebrates. Its major function is to provide support and, because cartilage is less rigid than bone, allowing some flexibility. Cartilage is more stable than an organism's muscle structure, and cartilage connective tissue traits are halfway between bone and muscle. Cartilage is utilized in body locations where both support and structure are required, but also some flexibility. The many kinds of cartilage include *hyaline*, used in joints; *fibrocartilage*, employed in high impact locations, e.g., meniscus of the knee and between vertebrae; and *elastic cartilage*, used in the ear pinna, the tip of the nose, and in between the spinal column vertebrae.

The existing evidence does not support the evolution of bone from some type of non-bone including cartilage. Biologists "have long remained puzzled by an attribute of bone that sets the vertebrate skeleton apart from the calcareous skeletons of virtually all other metazoans: the hard, inorganic component or 'ground substance' of bone … calcium phosphate…. In contrast, the mineral or hard fraction of almost all calcareous invertebrate skeletons … is primarily calcium carbonate" (Ruben and Bennett, 1987, p. 1187).

Evolutionists expect that, due to environmental constraints, vertebrate bone would use calcium carbonate as the ground substance, which is similar to that used in invertebrate organisms from which they are postulated to have evolved. In contrast to this expectation, little evidence exists that present marine concentration of phosphate has changed much since the first appearance of vertebrates (Ruben and Bennett, 1987, p. 1188). These authors note a variety of explanations have been offered for this major problem of bone evolution, "but none of these is particularly compelling" (Ruben and Bennett, 1987, p. 1187).

Bones: A Very Different Structural System than Other Connective Tissue

Bone employs a very different structural design than all other connective tissue types. The bone referred to in this review covers skeletal support bones and excludes the hyoid and ear bones. Furthermore, although some differences in vertebrate bones exist, such as between a bird's light bones and most mammal bones, bone design is close to identical for all vertebrates (Jantzen, 2014, p. 161).

The origin of the vertebrate posterior axial and appendicular skeletons are derived from mesoderm tissue (Knight and Schilling, 2013; Harland, 1994). The cranial bones develop from a cell type called the neural crest (Smith and Hall, 1993, pp. 400–401). The neural crest cell emerges from the developing neural tube, and then migrates elsewhere, causing a "remarkable series of transformations" that produce the cranial skeleton (Toshiyuki, et al., 2005; Bronner and LeDouarin, 2012). The neural crest multipotent cell type transiently forms in the developing vertebrate embryo. These cells extensively migrate in the embryo and, besides bone, give rise to cell lineages as diverse as melanocytes, smooth muscle, craniofacial cartilage, peripheral and enteric neurons, and glia neurons (Bronner and LeDouarin, 2012).

The neural crest is a critical factor in producing not only skeletal structure, but also many features in our skin and sensory organs that are unique to vertebrates. It is responsible for the distinctive human vertebrate head and neck. Furthermore, extensive comparisons of this "vertebrate innovation," and the gene regulatory network underlying neural crest formation, find it is "highly conserved, even to the base of vertebrates" (Bronner and LeDouarin, 2012). In other words, in contrast to evolutionary expectations, the neural crest cell system formation is virtually identical in the most primitive vertebrate to the highest primate.

Although amphioxi are considered the most primitive chordate, they lack bones (Bonnan, 2016, p. 36). Contending for the so-called "origin" of the vertebrate framework is the cartilaginous skeleton, such as exists in haggish and lamprey (both animals regarded as the most primitive living vertebrates). Fish, however, exist in two main types: cartilaginous, such as Chondrichthyes, and bony fish or Osteichthyes, such as the Actinopterygii and Sarcopterygii. As described by Professor Keating, et al., "Living vertebrates are divided into those that possess a fully formed and fully mineralized skeleton (gnathostomes) versus those that possess only unmineralized cartilaginous rudiments (cyclostomes)" (Keating, et al., 2015). No intermediate predicted by evolution has been discovered. In answer to the question, "What is the first creature that had bones?," Groenewald answered that nobody knows the answer,

> but scientists have hypothesized how it happened. Bone is specific to vertebrates; thus the best bet is that bone arrived somewhere in the evolution of the vertebrates. Bone

> probably first appeared as an external protective layer of cartilage and mineralized plates as can be seen in ostracoderms…. That is a bit of a mystery, but we know it happened. There are a lot of theories…. It was an important development in vertebrates. However, there is no definitive species or organism that can be described as the first boner. But scientists agree that bone [first] developed in a fish-like chordate, which gave rise to boney fish and later amphibians (Groenewald, 2017, p. 12).

Evolutionists postulate the key to the evolution of bone is the link between these two similar fishes because cartilaginous fish have a skeleton made up entirely of cartilage, and bone fish have a skeleton made up entirely of fully-developed bones. Although other differences exist, such cartilaginous fish have exposed gills lacking protection, and bony fish have a membrane that covers gill slits. The development from a complete lack of a bone structure to a complete bony skeleton, and nothing to bridge the two dichotomous designs, is a central problem for evolution.

Professor Bonnan, in his leading textbook on bone, mentions evolution 146 times, and every example is how one type of bone, such as a limb bone, supposedly evolved into another bone design in another kind of animal. He never mentions how the pre-bone cartilaginous animal evolved into the bone design, which is the real issue (Bonnan, 2016, pp. 36–39).

The Contrast Between Cartilage and Bone

Although cartilage in the fetus is replaced by bone, a process directed by genetics that occurs throughout our lives, is the evolutionary origin of bone from cartilage? Most evolutionists have rejected cartilage as the origin of bone due to the level of complexity of bone structures as compared to cartilage. Bone is a hard, connective tissue produced by osteoblasts, while cartilage is a soft, pliable connective tissue produced by chondroblast cells. Cartilage is an avascular isogenous (Latin "of equal origin") cluster of chondrocytes formed by the cell division of a single progenitor cell. In contrast, bone is vascular, not isogenic, formed by the division of many millions of progenitor cells. The many other differences between cartilage and bone are reviewed in Table 1, which illustrates the chasm between these two very different tissue types, creating major problems for the cartilage-to-bone evolution theory.

One difference is that, although bone contains some cartilage called type I, it is different than connective tissue cartilage, called type II (Currey, 2006, p. 174). Bone is also very different than dentin, which is used to construct present-day fish scales. Another difference is, in contrast to bone, once cartilage is laid down, it is fixed and not remodeled as bone is (Currey, 2006, pp. 191–193).

The Origin of Cartilage in the Body

Even the evolutionary origin of cartilage itself is debated: "Theories of the evolutionary origin(s) of cartilage abound. Most start from the premise that cartilage is exclusively a vertebrate tissue" (Hall, 2015, p. 74). Hall adds that the basic structural elements of matrix molecules in skeleton bones "are conserved with surprising fidelity," meaning the fossil record documents stasis, not evolution (Hall, 2015, p. 99). And an analysis of these matrix structures tells us these structures are identical to those existing today.

The Just-so Story of Bone Evolution

Evolutionist Ken Kardong noted that bone is found only in vertebrates. Why it should make an evolutionary debut in vertebrates and not in some other animal group is unknown. One just-so theory holds that bone arose first, not as a supportive tissue, but rather as the stored form of calcium or phosphate and later evolved to serve a support role (Kardong, 2012, p. 186).

From the extensive paleontological evidence, it was long "surmised that the vertebrates were most likely descended from amphioxus-like forms with a notochord. These were followed by jawless creatures with a cartilage-like endoskeleton, reminiscent of the modern hagfish or lamprey" (Wagner and Aspenberg, 2011, p. 393). The next major step postulated in bone evolution was the evolution of mineralized skeletal parts, which was "a major evolutionary leap and led directly to the rise of the vertebrate lineage" (Wagner and Aspenberg, 2011, pp. 393–394). Before bone existed, most structural support must have been achieved by hydrostatic pressure in water and/or hydrostatic structures, such as the notochord existing in primitive chordates. Bone also offered much more surface area for muscle attachment, and could support much larger, heavier organisms and, most importantly, terrestrial life.

Cartilage Evolves into Bone and the Fossil Record

One major problem with the once widely-accepted view that bone evolved from cartilage, aside from the contrast between the two theories noted above, is the fossil record. Because both bone and cartilage are abundant in the fossil record, if this transition occurred, evidence of bone evolution should be plentiful. Yet no evidence exists in the fossil record for the critical transition from cartilage to bone. The fossil record evidence is very clear: "Much information is available on the structure of skeletal tissues from extinct vertebrates. An examination of these skeletal tissues,

Table 1. Cartilage in contrast to bone chart.

Bones	Cartilage
Bones are rigid, non-flexible, tough and only eight percent water.	Cartilage is flexible, soft-elastic tissue and over seventy percent water.
Bones grow in both directions (bidirectional).	Cartilage grows in one direction only (unidirectional).
Haversian system and Volkmann's canals are used.	Haversian system and Volkmann's canals are absent.
Bone marrow, contains hematopoietic tissue from which all blood cells are derived.	Bone marrow is absent.
Lacunae possess canaliculi and each lacuna consist of only one cell, an osteocyte.	Lacunae do not possess canaliculi, and each lacuna has two to three chondrocytes.
Bones are active participants in the regulation of blood supply.	Does not produce blood supply except in perichondrium.
Bone matrix consists of a protein called ossein, and both organic and inorganic tissues occur in lamellae and are vascular. Contains deposits of calcium salts, largely calcium phosphate.	Matrix consists of an organic protein called chondrin. The matrix is a homogenous mass without lamellae. Lacks calcium salts.
Bones cells are Osteocytes.	Cartilage cells are Chondrocytes.
Bone is hard due to phosphate deposition and carbonates of calcium in matrix.	Cartilage is soft, except the calcified cartilage, and its matrix is made up of proteins and sugars.
Bone is responsible for the formation of the skeletal system, which gives shape to the body.	Structural cartilage is found only in ears, nose, larynx and trachea.

Adapted from https://biodifferences.com/difference-between-bones-and-cartilage.html

even in the earliest chordates, indicates homology with skeletal creatures in present day vertebrates" (Hall, 2015, p. 99). In other words, the study of skeletal tissues from extinct vertebrates has not revealed evidence for bone evolution from cartilage or anything else.

In short, bone is "one of the most fantastic building materials that evolution has *accidently* spit out" (Switek, 2019, p. 6; emphasis added). The basic vertebrate bone design has three major components: a fibrous matrix, a nutritive supply, and bone-making osteocytes, for all of which evolutionary evidence should exist if bone evolved from cartilage (Wake, 1979, p. 166). Once bone evolved in the evolutionary scenario, Switek then provides a lot of very hypothetical just-so scenarios to explain how it evolved to become the core support structure of modern vertebrates. One example is that bone evolved from crude fish jaws to more-evolved fish, mostly because their new, stronger jaws facilitated consuming other fish.

The Aspidin Theory

One theory that attempted to answer the problem of bone evolution postulated aspidin as the material from which bone evolved (Switek, 2019, p.44). How this occurred, and even the basic details, were never provided. This theory, first developed in 1930, proposed that bone evolved from aspidin, also called aspidine, a bonelike material lacking spaces for bone cells (Gross, 1930). Aspidin was considered the most primitive bonelike tissue known (Halstead, 1963, p. 46). Since aspidin is assumed to have preceded the "first incontrovertible evidence of bone in the fossil record by about 100 million [Darwinian] years," and because aspidin is effectively preserved as bone, "until definite evidence to the contrary is produced, it seems reasonable to take aspidin as the most primitive calcified tissue, rather than bone" (Halstead, 1963, p. 46). As late as 1974, Halstead wrote: "All the recent work on aspidin points to this tissue being a primitive type of bone…this tissue shows a gradual evolution from a substance that is close to dentine to one that is more allied to bone" (Halstead, 1974, p. 63).

Halstead theorized that a few cells became trapped during calcification which, after millions of years, may have evolved into bone cells (Halstead, 1963, p. 47). Some collagen, or other fibers in aspidin which produce the same basic arrangement, occurs "in modern dentine, and supports the idea that dentine could have been derived from an aspidin-like tissue at an early stage of evolution" (Halstead, 1963, p. 47). Halstead then speculated that aspidin "almost certainly possessed cells with the same role as osteoblasts, osteocytes and osteoclasts, with the gradual organization of its collagen fibrils into alternate layers, and with its ability to remodel, aspidin must surely be considered as a primitive type of bone, or as the precursor of true bone" (Halstead, 1963, p. 46). Evolutionist Philippe Janvier observed that heated debates existed on this subject for some time, with "detailed arguments for and against each theory" (for a review see Orvig, 1989) (Janvier, 2002, p. 276).

The Aspidin Theory of Bone Origins Refuted

After Halstead's paper was published in *Nature*, the nature of aspidin has been "mired by debate over interpretation of the most primitive bone-like tissue… aspidin. …[which] has variously been interpreted as cellular bone, acellular bone, dentine or an intermediate of dentine and bone" (Keating, et al., 2018, p. 1501). The crux of the controversy is what is in the "unmineralized spaces pervading the aspidin matrix, which have alternatively been interpreted as having housed cells, cell processes or Sharpey's fibers."

To research aspidin, Keating and his co-workers used synchrotron X-ray tomographic microscopy revealing the space's morphology was "incompatible with interpretations that they represent voids left by cells or cell processes. Instead, these spaces represent intrinsic collagen fiber bundles that form a scaffold about which mineral was deposited" (Keating, et al., 2018, p. 1501). As a result of this study, the hypothesis that aspidin is a type of cellular bone, dentine, or transitional tissue has been rejected.

These researchers concluded that the "spaces represent intrinsic collagen fiber bundles that form a scaffold about which mineral was deposited.… We reject hypotheses that it is a type of dentine, cellular bone or transitional tissue" (Keating, et al., 2018, p. 1501). They concluded that the "full repertoire of skeletal tissue types was established before the divergence of the earliest known skeletonizing vertebrates, indicating that the corresponding cell types evolved rapidly following the divergence of cyclostomes and gnathostomes" (Keating, et al., 2018, p. 1501). In short, aspidin was not the precursor of "acellular bone, dentine and enameloid [which] were already established before the divergence of the known skeletonizing vertebrate clades" (Keating, et al., 2018, p. 1502). In other words, aspidin is not evidence of a transitional form between non-bone and bone, but rather of structures that are part of modern skeletal tissue.

The Sudden Appearance of Skeletal Tissue Theory

The lack of evidence for bone evolution is now explained by some to be due to a form of punctuated evolution; it occurred so rapidly that no evidence exists in the fossil record for the evolution of acellular bone, dentine, and enameloid. These tissue types appear simultaneously in the fossil record "without any pre-cursor," an event Keating and his coworkers call "punctuated appearance."

One event that is an attempt to explain the relatively-sudden appearance of skeletal tissue is that "many of the key genes responsible for the synthesis of collagenous tissues emerged through duplication associated with whole-genome duplication (WGD) events early in vertebrate evolution, and redundant copies were subsequently co-opted for biomin-

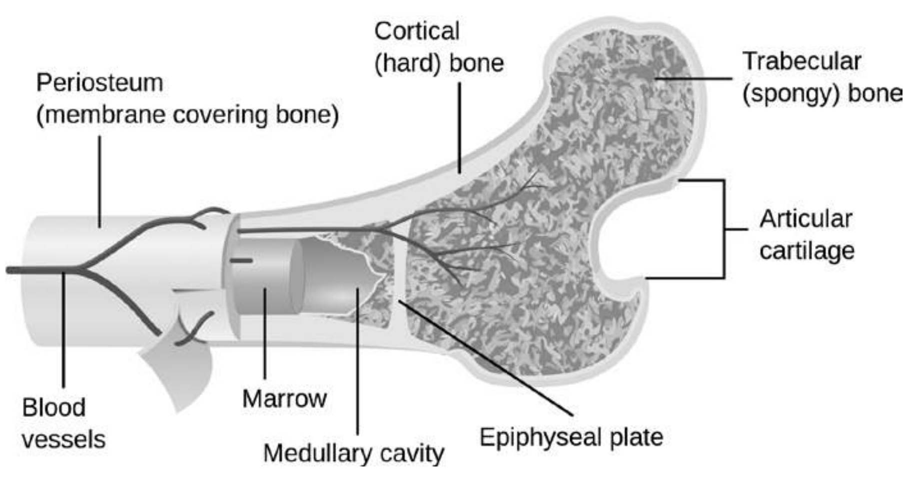

Figure 1. Cross section of a human bone. From Wiki Commons.

eralization" (Keating, et al., 2018, p. 1502). This research acknowledges that no evidence exists for bone evolution.

The Origin of Bone Design

Bone is a complex structure, actually an organ, that is far more complex than cartilage. Most all vertebrates, and only vertebrates, have a support framework constructed out of bone. As Alexander wrote, few creations "display the perfect unity of form and function found in the vertebrate skeleton. Ingeniously designed … bones are marvels of engineering, their material and construction are the ideal compromise between strength and lightness, their shapes precisely suited to the tasks required of them, their forms by turns bizarre, utilitarian, and lovely." (Alexander, 1994, book jacket). Alexander attempts to argue that the wonder of bones was designed by evolution even though no evidence exists to support this view. He adds that the

> word 'design' may suggest a Creator figuring out the best way to build a snake. I do not know whether there is a Creator (the scientific methods… are incapable of deciding the question) and I have a very different concept of the design of skeletons. This is design by evolution, a powerful and apparently inevitable process that molds the structures of animals to suit their way of life" (Alexander, 1994, p. 14).

Alexander's evolutionary explanation of the incredible design of bone is that bone is a result of millions of mutations winnowed out by natural selection. This view fails compared with the creation view that the origin of bone is a result of intelligent design. Another scientist added,

> Bone is a marvel, an adaptable and resilient building material … It gives our bodies their shapes and the ability to move. It grows and changes with us, an undeniable document of who we are and how we lived. Arguably, no other part of the human anatomy has such rich scientific and cultural significance, both brimming with life and a potent symbol of death (Black, 2019).

As an evolutionist, Black adds to the origin of this marvel of design, that everything

> about the bones inside us, from their arrangement to their microscopic structure, is a testament to the way evolution mixes blind chance with the winnowing edge of natural selection. By mixing and matching old parts, forced along only by what's useful in any given moment, what's old becomes something new.

The vertebrate skeleton bone was designed using calcium phosphate, and not calcium carbonate, because calcium phosphate is more stable in the presence of lactic acid resulting from intense bursts of muscle activity. Consequently,

> a skeleton of calcium would afford some mechanical protection, but one of calcium phosphate in particular (but not of calcium carbonate) would make bone matrix more stable. It would also reduce the physiological disadvantages bone dissolution otherwise might create for an animal that depended on bursts of activity (Kardong, 2012, p. 186).

The Anatomy of Bone

Discussions of the basic parts of bones illustrates the contrast between bones and cartilage. In the embryo and fetus, cartilage gives shape to the skeletal system which is replaced by the bone system as the body develops. The 206 bones include compact bone, the heaviest and hardest bone type. Strength is critical to support both the body and muscles that enable it to walk, run, and jump. Although only about 15 percent of the adult body weight is bone, ounce for ounce, bone is stronger than steel. One cubic inch of bone can withstand the weight of nearly five standard pickup trucks. It requires about 4,000 newtons of force to break a healthy adult human femur. Designs such as the Warren Truss are used to greatly increase bone strength, yet minimize weight.

About 80% of the bone in the human body is compact bone by volume. Compact bone makes up the outer bone layer and helps to protect the fragile structures inside. A layer of dense irregular connective tissue called the periosteum surrounds the bone.

Bone strength is partly due to the use of a composite design similar to the rebar-concrete design. The rebar consists of hydroxyapatite and salts, such as Ca, PO_4, OH, CO_3, Na, and Mg, and the concrete is organic matter, mostly collagen. Cartilage is also the framework used to build the bone framework during early development.

Each bone cell must be supplied with sufficient oxygen, nutrients, and a means for the effective removal of toxins and waste products. The hollow channel located in the osteon center that runs parallel to the bone length, called the Haversian canals, generally contains several capillaries to supply blood and nerve fibers to the bone. Haversian canals are formed when individual lamellae produce concentric rings around larger longitudinal canals by the bone tissue (See Figure 2).

Compact bone contains small arteries that permeate throughout the bone. The Volkmann canals supply oxygen, minerals, and nutrients for bone health and growth. They also surround nerve cells located throughout the bone and communicate with osteocytes in the spaces within the dense bone matrix, called lacunae, that contain living bone cells. The lacunae run through small channels called *canaliculi*. This unique arrangement is conducive to the storage of mineral salt deposits, including calcium, that give bone tissue its enormous level of strength. The minerals stored in bone, including calcium, can be moved to compensate for deficiencies elsewhere, such as during pregnancy when the baby's needs are put first by the body.

Because bones are living tissue, their structure must constantly be renewed and repaired. To achieve this, osteoclasts are involved in the maintenance of bone by reabsorption of bone tissue, and osteoblasts replace old bone with new bone. Bone, like most of the rest of the body, is constantly being turned over so it is totally replaced about every 10 years. This time span increases as we grow older, which facilitates aging. The bone matrix tissue contains both an organic component (mostly collagen) and an inorganic component (mostly the various salts listed above). Bone growth occurs at each end of the bone in an area located between the epiphysis (the end of the bone) and diaphysis (the middle of the bone/shaft of the bone). This outline briefly illustrates the basic complexities of bone.

The Evolution from Fish to Tetrapods

Another major gap in the fossil record is between fish and tetrapods. The central transition issue is from a fish skeleton to a tetrapod skeleton. The "fish-to-tetrapod transition is one of the fundamental problems in evolutionary biology" as well as "one of the prominent events in vertebrate evolution" (Wood and Nakamura, 2018, p. 1). Furthermore, the "invasion of the land from the water necessitated the evolution of the novel structures in skeletons, musculatures, innervations, visceral organs, and respiratory systems in order to adapt to a terrestrial life" (Wood and Nakamura, 2018, p. 1).

The vertebrate skeletal system is of "paramount importance for analyses in evolutionary biology" (Hirasawa and Kuratani, 2015, p. 1). In short, another major gap exists that Wood and Nakamura call "the fin-to-limb conundrum." Jennifer Clack, an authority of the fish-to-amphibian transition theory, stated, "The question of where tetrapods evolved is even more difficult to answer than that of when" (Clack, 2012, p. 128). And Michael Denton added after a century and a half of research, "the gap between the tetrapod limb and the fin remains" (Denton, 2016, p. 159).

Genetic Research

Evolutionists have recently looked to genetics to solve the gaps noted above with the goal of attempting to fill them. So far, these attempts have been very disappointing because, although historical

> continuities of skeletal elements as step-wise morphological changes along a phylogenic lineage are inferable from detailed comparative analyses…. Within these continuities, discontinuities of genetic and developmental bases arise in which morphologically homologous bones are produced through different developmental processes (Hirasawa and Kuratani, 2015, p. 1).

Newer research on bone evolution focuses on the possible evolution of the several scores of genes necessary to produce the many proteins required to manufacture and maintain bones. For example, current research on bone evolution indicates "a close relationship between bone, dentine, and enamel in terms of a mineralized-tissue continuum in which contemporary dental tissues have evolved from an ancestral continuum through lineage-specific modifications" (Wagner and Aspenberg, 2011, p. 393). Recent searches for the molecular origins of skeletal development have focused on the RUNX family of genes, which regulate the major structures and biochemistry involved in skeletogenesis. As indicated by the finding that RUNX2-deficient mice lack bone development, these genes are crucial for skeletogenesis. Several other newly-discovered gene networks are also believed to be central to understanding skeletal development (Wagner and Aspenberg, 2011, p. 393). In short, many genes are known to be required to produce and maintain bone, and the origin of these genes must be accounted for to explain bone evolution. This, though, is the subject for another paper (Karsenty, 1999).

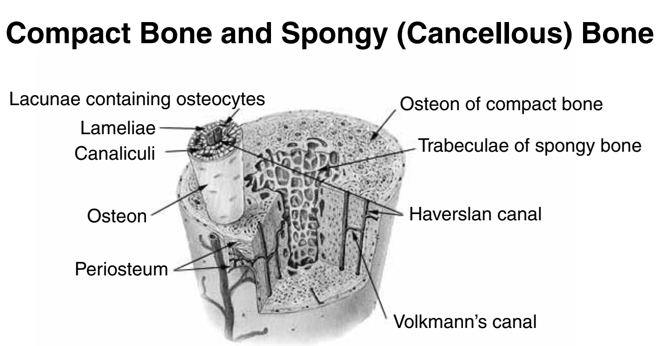

Figure 2. Section of a human bone showing the Haversian canal. From Wiki Commons.

Summary and Conclusions

Due to a complete lack of empirical evidence, the various theories of bone evolution from non-bone are based largely on speculation. Consequently, as has occurred, any proposed theories are easily modified as new discoveries are made. As Wagner and Aspenberg note, "Bones may not have evolved, but theories of bone evolution certainly have." Thus, they write, if their article on bone evolution was "written a decade ago, it would have been considerably different" from one written today, due to the many attempts to explain bone evolution based on speculation and just-so stories (Wagner and Aspenberg, 2011, p. 393).

The fact is, only paleontology studies offer the "possibility of gaining some insight into the ancient processes that led to [a] mineralized skeleton." But, after almost two centuries of looking, no evidence has been forthcoming that provides meaningful help in supporting any existing theory of the evolution of bone from some pre-bone structure. The fossil record offers no evidence of transition, for example, from cartilage to bone, even though teeth and bones are, by far, the best preserved material in the fossil record. The finding of soft tissue, including blood cells and collagen, in dinosaur bone could help to elucidate this issue (Armitage, and Anderson, 2013; Lindgren, et al., 2011).

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