The evolution of the human urinary bladder

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The urinary bladder is a vital system for waste removal employed in virtually all terrestrial tetrapods. A literature review was conducted to evaluate the evolutionist claims concerning its development. The review found that not only is there no evidence of its evolution, but the problem is so difficult that even just-so stories were not found. Two very different urine excretion systems exist, and no evidence was located to support the postulate that the simple system in fish evolved into the far more complex system existing in mammals. Furthermore, both systems were designed to effectively deal with the elimination needs of the organism in which they are employed.

Waste control is of vital importance in all living organisms. With rare exceptions, all terrestrial tetrapods have a urinary bladder, which stores urine and enables its release under voluntary control.[1] Many animals, such as fish, release urine as it is produced. Humans and most mammals, birds, reptiles, and amphibians can store it to some extent and release it when the appropriate opportunity arises. Many animals use this ability to mark their territory, a communication system that requires bladder control.

The urinary bladder, often referred to simply as 'the bladder', stores urine produced in the kidneys until its disposal by urination. In humans and a number of other vertebrates, this hollow muscular distensible organ (figure 1) rests on the pelvic floor. Urine enters the bladder from the kidneys via the ureters and exits via the urethra. The typical human bladder holds between 300 and 500 ml (10.14 to 16.91 fl. oz.) of liquid before the urge to empty is triggered, but it can hold considerably more. In contrast, most invertebrate animal life-forms have no means of control over releasing liquid waste. It is released into the environment very soon after it is produced. Many vertebrates (see shortly) lack a bladder, their ureters instead opening into a cloaca that also holds fecal matter.

The anatomy of the human bladder

The urinary bladder is an integrated system consisting of muscular tubes called 'ureters', which propel the urine forward from the kidneys to the bladder by a set of coordinated wave contractions called 'peristalsis'. This enables the urine's movement forward from the kidneys regardless of the body's position; standing straight up, or lying horizontally. The bladder is divided into a broad *fundus* located at the top, the main part called the *body*, an *apex* at the bottom and a *neck* where the urine is drained into the urethral orifice.

The bladder's inner lining, the *mucosa*, consists of special epithelial cells called 'transitional epithelium'. This layer can stretch as the bladder expands and protects the other layers from the effects of urine if it is too acidic or too alkaline. Next is the *submucosa*, made of connective tissue in which there are nerves and blood vessels. Beyond this is the *muscularis*, the central structure which is made up of three layers of muscle fibres. The superior (top) part of the bladder is covered outside with a *serous membrane* which is continuous with the peritoneum that lines the abdominal cavity generally. It protects the bladder against friction between it and the organs in proximity to it. The lateral (side) and inferior (bottom) parts of the bladder are surrounded by a layer of fibrous connective tissue called the *adventitia*.

The bladder walls are able to greatly expand due to a series of thick mucosal folds called 'bladder rugae'. These folds look like wrinkled skin when the bladder contracts, which causes it to assume a pyramidal shape. When filled with urine, the bladder expands, causing it to resemble a balloon. The urinary bladder wall is normally 3 to 5 mm thick, but, when distended, thins to less than 3 mm.

The muscularis of the bladder wall is constructed from smooth muscle fibres arranged in spiral, longitudinal, and circular bundles to form the required shape, allowing the bladder to empty when necessary. The muscularis is also known as the detrusor muscle. It remains relaxed when the bladder is filling, but contracts to force urine out of the bladder and into the urethra when the bladder is full.[2]

At the bladder neck there is a smooth triangular region called the *trigone*, formed by the two openings of the ureters and the internal urethral orifice opening into the urethra. This contains muscle fibre that form a sphincter. This acts like a valve, so that, when contracted, it prevents urine from leaking into the urethral tube and out of the body. In males, the neck of the urinary bladder is contiguous with the prostate gland such that the first part of the urethra travels through the centre of the prostate.

To function, the entire system requires a set of arteries and veins, and nerves coordinated by the brain and other parts of the nervous system. Lacking this complete system, or any part noted above, the bladder will not function properly, or at all.

The waste-control function in all living organisms is of vital importance.[1] Urine primarily consists of nitrogenous wastes, including ammonia, urea, uric acid and creatinine, plus toxins, drugs, hormones, salts, and hydrogen ions.[3] Due to the potential lethality of these substances if allowed to build up, the complex system of urine removal described above is critical.

Urinary bladder systems in reptiles

All turtles, tortoises, and certain lizards, such as the Gila monster, have a urinary bladder designed to recycle urine through their body to reuse, and hence conserve a significant portion of the water in urine.[4] Most other lizards also possess a urinary bladder,[5] but legless lizards, often called 'snake-lizards', lack a bladder and use a cloaca through which urine flows out of the creature's body as soon as it's produced. All snakes lack a bladder; thus, their urine is also emptied directly into the cloaca for elimination.[6] Given the design of snakes and their mode of life, the advantages of this design are obvious.

Alligators and crocodiles have kidney and excretory systems similar to those in other reptiles, except they do not have a bladder.[7] Certain other reptiles possess a midventral wall in the cloaca, which opens into a urinary bladder. Beuchat, in his survey, reported that a urinary bladder is present both in all tuataras and all chelonians. In all fish, birds, and most reptiles, the urinogenital ducts and the anus both empty into the cloaca. This posterior orifice is not only the opening for the digestive and urinary tracts, but also the reproductive tract.[1,8] Thus, a clear contrast exists between animals that possess a urinary bladder and those that lack it. Furthermore, the presence or absence of a urinary bladder does not form the logical ranking from lower life-forms lacking a urinary bladder to higher

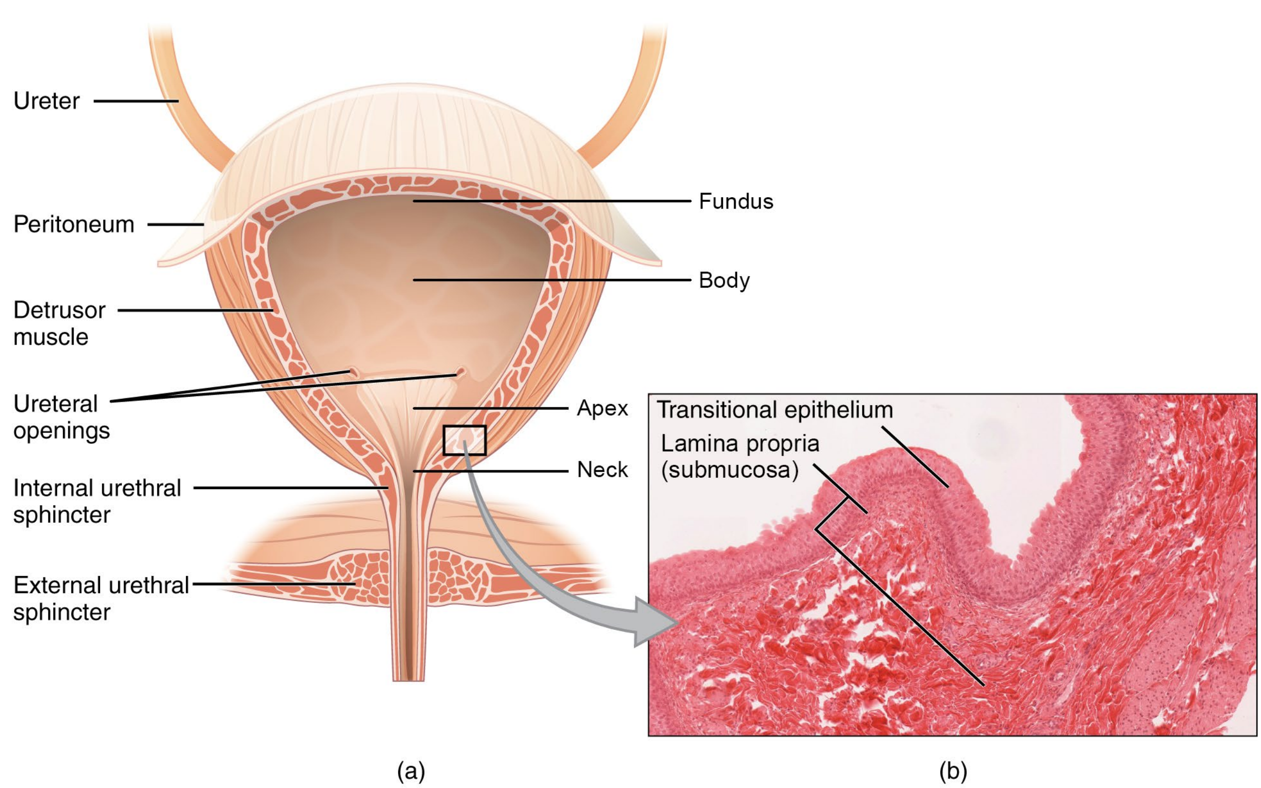

Figure 1. The human male urinary bladder (a), displaying transitional epithelium and part of its wall (b)

forms possessing it. Beuchat concluded that phylogenic (evolutionary) generalizations cannot be made from the existing data.[8]

Evolution of the bladder

Animals either have a urinary bladder system or lack one. Consequently, the challenge to evolutionists is to attempt to bridge this gap by short steps, each one a step that allows the animal to effectively eliminate toxins so as to prevent internal toxicity. In short, the evolutionary question to be answered is: "How can this organ evolve from a thin-walled structure in fish to the complex urinary bladder existing in mammals?"[1] Some major design differences exist in urinary bladders, so some evolutionists have postulated that it evolved twice![9] The just-so story proposed is that the area anterior to the cloaca expanded slowly until a balloon-shaped structure developed—which proceeded to evolve all of the many structures seen today in the human bladder as outlined above.

Internet searches using the phrase 'evolution of the urinary bladder' produced mostly articles on the *development* of the human bladder in the embryo. Even books such as *Understanding Human Anatomy Through Evolution*, in spite of a detailed discussion of the human urinary bladder, mention not a word about its possible evolution.[3] The author did mention the "ability to concentrate wastes and control water loss was crucial to the evolution of terrestrial animals such as humans", but not a word on *how* it could, or did, evolve.[3] Lieberman likewise ignored the topic of its evolution in his book on human evolutionary biology, a field in which he is a professor.[10] Wilder discussed its function but completely ignored its evolution.[11]

Romer & Parsons speculate that since the bladder evolved very early in evolutionary history it has disappeared in animals that evolved later which do not, today, have the organ. Specifically, in a few lizards, snakes, crocodilians and birds (except ostriches), evolutionists claim that the entire bladder system has totally disappeared.[12] In these cases, urine is poured directly into the cloaca and then exits into the environment. Theories about how or why it disappeared were not mentioned by Romer and Pearson in their chapter.[13]

A study by McCarthy and McCarthy was one of the few exceptions that did not ignore the evolution problem. After noting that almost all terrestrial tetrapods have a urinary bladder with a storage function, but many marine and aerial species lack a urinary bladder, or have only a very small storage capacity, they postulate that this difference in bladder morphology:

> "… indicates it has evolved from a thin-walled structure used for osmoregulatory purposes, as it is currently used in many marine animals. It is hypothesized that the storage function of the urinary bladder allows for an evolutionary selective advantage in reducing the likelihood of successful predation. Random walks simulating predator and prey movements with simplified scent trails were utilized to represent various stages of the hunt: Detection and pursuit."[1]

Disagreement exists about this proposal. McCarthy and McCarthy's model was not based on incremental change from a lack of bladder to a fully functional bladder, but contrasted the functionality of a storage bladder under voluntary control vs a continual excretion of waste. The concern here is the evolution of the bladder, not the evolution "from an osmoregulatory organ to one of storage".[1] The function of the bladder is controlled release of urine, and a bladder that continually releases urine lacks this function. By allowing the release of urine at select locations and intervals, the urinary bladder serves to reduce the likelihood of soiling the area where the animal sleeps and spends much of its time.[9]

In spite of evolutionary proposals by McCarthy and McCarthy about 'selective pressure', an unbridgeable chasm exists between the simple tubes used in invertebrates and the far more complex urinary-bladder system used in virtually all vertebrates. No direct evidence of the evolution of one system into the other exists, nor have any viable just-so stories been proposed to explain the evolution of the simple invertebrate urinary system into the complex vertebrate kidney-urinary system.

The common reason evolutionists present for the lack of evidence to bridge this chasm is that soft tissue is usually not preserved in the fossil record. However, there have been numerous discoveries of fossils in which the structure of soft tissues, such as the brain and internal organs, or even the whole creature in the case of jellyfish and cephalopods, has been beautifully preserved. In recent years there has, in addition, been the discovery of non-fossilized tissues (i.e. intact, thus still soft and elastic when demineralized, with identifiable proteins), mostly in dinosaur bones[14] and a handful of other specimens.[15] These may motivate the search for, and further research on, other types of soft tissue.

Another problem with leaning on the soft-tissue preservation difficulty to explain the lack of evidence is the fact that thousands of so-called 'living fossils' exist that are believed to be anatomically close to their claimed multiple millions-of-years-old designs. Thus, if bladder evolution occurred, evidence of it should exist in living animals that bridge the two very different systems. Romer and Parsons highlight the problem, noting fossils have a "paleontologic record [that] is ambiguous and open to controversy".[16]

Summary

All life either has a bladder system or lacks a storage-and-controlled-release urinary system. To work properly the bladder system requires all of its components to operate. How one system could gradually evolve into the other system by a slow and gradual means via mutations and natural selection is almost totally ignored in the literature. Even just-so stories are almost unknown. The rare attempts to postulate a possible evolutionary path are little more than suggestions and speculation and are often readily admitted as such. The evidence supports the conclusion that the first bladder was a fully developed functional system that had to operate at a high degree of effectiveness and efficiency in order for the animal to survive.

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