

The Mosaic Nature of *Australopithecus sediba*

THE SITE OF MALAPA, SOUTH AFRICA, HAS YIELDED PERHAPS THE RICHEST assemblage of early hominin fossils on the continent of Africa. The fossil remains of *Au. sediba* were discovered in August of 2008, and the species was named in 2010 (1)* and given a provisional age of ~1.78 to 1.95 Ma (2). In 2011, detailed studies of four critical areas of anatomy of these remains were published (3–6), and a refined date of ~1.977 to 1.98 Ma was proposed (7). The six articles presented in full in the online edition of *Science* (www.sciencemag.org/site/extra/sediba), with abstracts in print (pp. 164–165), complete the initial examination of the prepared material attributed to three individuals: the holotype and paratype skeletons, commonly referred to as MH1 and MH2, and the adult isolated tibia referred to as MH4. They, along with the cumulative research published over the past 3 years, provide us with a comprehensive examination of the anatomy of a single species of early hominin.

Irish *et al.* examine highly heritable nonmetric dental traits in *Au. sediba*. The species appears phylogenetically distinct from East African australopiths but close to *Au. africanus*, forming a southern African australopith clade. The latter shares some derived states with a clade comprising four fossil samples of the genus *Homo*. This result has implications for our present understanding of hominin phylogeny through the terminal Pliocene and suggests a possibility that *Au. sediba*, and perhaps *Au. africanus*, did not descend from the *Au. afarensis* lineage. De Ruiter *et al.* examine mandibular material attributable to MH2, including the previously unknown mandibular incisors and premolars of *Au. sediba*. As seen elsewhere in the cranium and skeleton, these mandibular remains share similarities with those of other australopiths but differ from *Au. africanus* in both size and shape, as well as in their ontogenetic growth trajectory. These results further support the claim that *Au. sediba* is taxonomically distinct from *Au. africanus*. Where the *Au. sediba* mandibles differ from those of *Au. africanus*, they appear most similar to those of representatives of early *Homo*.

Churchill *et al.* explore the upper limb elements of *Au. sediba*, describing the most complete and undistorted humerus, radius, ulna, scapula, clavicle, and manubrium yet described from the early hominin record, all associated with one individual. With the exception of the hand skeleton (3), the upper limbs of the Malapa hominins are largely primitive in their morphology. *Au. sediba* thus shares with other australopiths an upper limb that was well suited for arboreal climbing and possibly suspension, although perhaps more so than has previously been suggested for this genus.

Remains of the rib cage of *Au. sediba* are described by Schmid *et al.* and reveal a mediolaterally narrow upper thorax like that of the large-bodied apes and unlike the broad cylindrical chest seen in humans. In conjunction with the largely complete remains of the shoulder girdle, the morphological picture that emerges is one of a conical thorax with a high shoulder joint (producing an ape-like “shrugged” shoulder appearance) and thus a configuration that is perhaps uniquely australopith and would not have been conducive to human-like swinging of the arms during bipedal striding and running. The less well-preserved elements of the lower rib cage suggest a degree of human-like mediolateral narrowing to the lower thorax, indicating a rather unsuspected mosaic anatomy in the chest that is not like that observed in *Homo erectus* or *H. sapiens*.

Williams *et al.* analyze elements of the cervical, thoracic, lumbar, and sacral regions of the vertebral column, showing that *Au. sediba* had the same number of lumbar vertebrae as modern humans but possessed a functionally longer and more flexible lower back. Morphological indicators of strong lumbar curvature suggest that *Au. sediba* was derived in this regard relative to *Au. africanus* and was more similar to the Nariokotome *H. erectus* skeleton.

Finally, DeSilva *et al.* describe the lower limb anatomy of *Au. sediba* and propose a specific biomechanical hypothesis for how this species walked. In isolation, the anatomies of the heel, midfoot, knee, hip, and back are unique and curious, but in combination they are internally consistent for a biped walking with a hyper-pronating gait. The implications are that multiple forms of bipedalism were once practiced by our early hominin ancestors.

This examination of a large number of associated, often complete and undistorted elements gives us a glimpse of a hominin species that appears to be mosaic in its anatomy and that presents a suite of functional complexes that are different from both those predicted for other australopiths and those of early *Homo*. Such clear insight into the anatomy of an early hominin species will clearly have implications for interpreting the evolutionary processes that affected the mode and tempo of hominin evolution and the interpretation of the anatomy of less well-preserved species.

— LEE R. BERGER



Composite reconstruction of *Au. sediba* based on recovered material from MH1, MH2, and MH4 and based on the research presented in the accompanying manuscripts. Because all individuals recovered to date are approximately the same size, size correction was not necessary. Femoral length was established by digitally measuring a complete femur of MH1 still encased in rock. For comparison, a small-bodied female modern *H. sapiens* is shown on the left and a male *Pan troglodytes* on the right.

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*References may be found on page 165 after the abstracts.

ABSTRACTS

Dental Morphology and the Phylogenetic “Place” of *Australopithecus sediba*

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To characterize further the *Australopithecus sediba* hypodigm, we describe 22 dental traits in specimens MH1 and MH2. Like other skeletal elements, the teeth present a mosaic of primitive and derived features. The new non-metric data are then qualitatively and phenetically compared with those in eight other African hominin samples, before cladistic analyses using a gorilla outgroup. There is some distinction, largely driven by contrasting molar traits, from East African australopiths. However, *Au. sediba* links with *Au. africanus* to form a South African australopith clade. These species present five apomorphies, including shared expressions of Carabelli’s upper first molar (UM1) and protostylid lower first molar (LM1). Five synapomorphies are also evident between them and monophyletic *Homo habilis/rudolfensis* + *H. erectus*. Finally, a South African australopith + *Homo* clade is supported by four shared derived states, including identical LM1 cusp 7 expression.

>> Read the full article at <http://dx.doi.org/10.1126/science.1233062>

Mandibular Remains Support Taxonomic Validity of *Australopithecus sediba*

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Since the announcement of the discovery of *Australopithecus sediba*, questions have been raised over whether the Malapa fossils represent a valid taxon or whether inadequate allowance was made for intraspecific variation, in particular with reference to the temporally and geographically proximate species *Au. africanus*. The morphology of mandibular remains of *Au. sediba*, including newly recovered material discussed here, shows that it is not merely a late-surviving morph of *Au. africanus*. Rather—as is seen elsewhere in the cranium, dentition, and postcranial skeleton—these mandibular remains share similarities with other australopiths but can be differentiated from the hypodigm of *Au. africanus* in both size and shape, as well as in their ontogenetic growth trajectory.



>> Read the full article at <http://dx.doi.org/10.1126/science.1232997>

The Upper Limb of *Australopithecus sediba*

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The evolution of the human upper limb involved a change in function from its use for both locomotion and prehension (as in apes) to a predominantly prehensile and manipulative role. Well-preserved forelimb remains of 1.98-million-year-old *Australopithecus sediba* from Malapa, South Africa, contribute to our understanding of this evolutionary transition. Whereas other aspects of their postcranial anatomy evince mosaic combinations of primitive (australopith-like) and derived (*Homo*-like) features, the upper limbs (excluding the hand and wrist) of the Malapa hominins are predominantly primitive and suggest the retention of substantial climbing and suspensory ability. The use of the forelimb primarily for prehension and manipulation appears to arise later, likely with the emergence of *Homo erectus*.



>> Read the full article at <http://dx.doi.org/10.1126/science.1233477>

Mosaic Morphology in the Thorax of *Australopithecus sediba*

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The shape of the thorax of early hominins has been a point of contention for more than 30 years. Owing to the generally fragmentary nature of fossil hominin ribs, few specimens have been recovered that have rib remains complete enough to allow accurate reassembly of thoracic shape, thus leaving open the question of when the cylindrical-shaped chest of humans and their immediate ancestors evolved. The ribs of



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Australopithecus sediba exhibit a mediolaterally narrow, ape-like upper thoracic shape, which is unlike the broad upper thorax of *Homo* that has been related to the locomotor pattern of endurance walking and running. The lower thorax, however, appears less laterally flared than that of apes and more closely approximates the morphology found in humans.

>> Read the full article at <http://dx.doi.org/10.1126/science.1234598>

The Vertebral Column of *Australopithecus sediba*

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Two partial vertebral columns of *Australopithecus sediba* grant insight into aspects of early hominin spinal mobility, lumbar curvature, vertebral formula, and transitional vertebral position. *Au. sediba* likely possessed five non-rib-bearing lumbar vertebrae and five sacral elements, the same configuration that occurs modally in modern humans. This finding contrasts with other interpretations of early hominin regional vertebral numbers. Importantly, the transitional vertebra is distinct from and above the last rib-bearing vertebra in *Au. sediba*, resulting in a functionally longer lower back. This configuration, along with a strongly wedged last lumbar vertebra and other indicators of lordotic posture, would have contributed to a highly flexible spine that is derived compared with earlier members of the genus *Australopithecus* and similar to that of the Nariokotome *Homo erectus* skeleton.

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The Lower Limb and Mechanics of Walking in *Australopithecus sediba*

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The discovery of a relatively complete *Australopithecus sediba* adult female skeleton permits a detailed locomotor analysis in which joint systems can be integrated to form a comprehensive picture of gait kinematics in this late australopith. Here, we describe the lower limb anatomy of *Au. sediba* and hypothesize that this species walked with a fully extended leg and with an inverted foot during the swing phase of bipedal walking. Initial contact of the lateral foot with the ground resulted in a large pronatory torque around the joints of the foot that caused extreme medial weight transfer (hyperpronation) into the toe-off phase of the gait cycle (late pronation). These bipedal mechanics are different from those often reconstructed for other australopiths and suggest that there may have been several forms of bipedalism during the Plio-Pleistocene.



>> Read the full article at <http://dx.doi.org/10.1126/science.1232999>

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