

# Spotlight on Science at the Smithsonian

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## Spotlight on Science at the Smithsonian

Spotlight on Science at the Smithsonian is a bi-weekly electronic newsletter about Science at the Smithsonian. It is produced for the Smithsonian community by the Office of the Under Secretary for Science. To subscribe to the newsletter or Podcast, visit [science.si.edu](http://science.si.edu).

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Halting Biological  
Hitchhikers



Reimagining the Yin  
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## Introduction from the Under Secretary for Science



In this issue of Spotlight we explore research that clusters around the theme of travel.

travel down through the ages remarkably intact, while others have been dramatically changed by that same journey.

First we'll learn about a new tool to deter an explosion of dangerous globetrotting hitchhikers. Not criminals on the highways, but the more threatening scourge of invasive species, like zebra mussels and kudzu, which employ various devious methods to expand their range worldwide.

Looking to space, we'll learn how researchers are deciphering the forced exodus of a star from the core of our galaxy, and how this travelogue provides insight into the unimaginable forces that hold our Milky Way together.

Next we'll see how certain features of our shared genetic heritage have managed to

And finally, we'll see how historians of science find a cultural fingerprint on the designs of the machines that ultimately allowed humankind to venture beyond the nurturing blanket of our own atmosphere.



Halting Biological Hitchhikers



Reimagining the Yin and Yang of Evolutionary Biology



Deciphering the Story of a Rejected Star



From Sputnik to Satellite Phones, Space Race Technology Mirrors Its Makers



Carried by ships for stability, ballast water is a major vector of introduced species as organisms are often transported from one port to another. SERC researchers analyze ballast water and study the effectiveness of different treatments to reduce potential invaders.

## Halting Biological Hitchhikers

### Additional Resources

Where to buy this book? The Smithsonian Environmental Research Center web site: <http://www.serc.si.edu/>

Today, destructive invasive alien species such as gypsy moths and brown tree snakes zip around the globe at the speed of commerce. They often hitch rides with unwitting people, animals or goods. When the hitchhiker is the Asian tiger mosquito, human health and livelihood are at stake, while invasive plants and animals threaten entire ecosystems with devastation.

The ultimate goal of a world-wide network of researchers, health care professionals and cargo inspectors is stopping these invasions before they start, on the organism's native soil. Now there is a revolutionary analytical weapon in their arsenal.

Greg Ruiz of the Smithsonian Environmental Research Center and James Carlton of the Maritime Studies Program of Williams College, have developed an ingenious technique for assessing and prioritizing invasion threats. It focuses on the vector, or transportation mechanism of a given threat, rather than the threat itself.

Ruiz and Carlton share their methods in a chapter of the new book "Invasive Alien Species" published by Island Press. The duo state that, "Clearly, the easiest way to prevent new invasions is vector interception or disruption, whereby the capacity of the vector to move species is greatly constrained."

Whether the vector is tainted ballast water in a super tanker or migrating flocks of geese, their approach focuses on evaluating a vector's threat profile by specific and universal criteria.

1. Reason for transport. Is it accidental or deliberate?
2. Geographic path over which a species is transported.
3. Mechanism of transport, or the type of vector, such as stagnant water in recycled tires, or packing material.
4. Vector tempo. The size, rate and speed over time that the vector transports organisms.
5. Diversity, density and condition of organisms transferred.
6. Vector strength or the relative number or rate of invasions that result from a given vector in a particular region.

Those battling invasives are faced daily with a massively complex matrix of environmental, social, economic and even political factors that affect the mechanisms which conspire to spread invasive species. The work of Ruiz and Carlton provides a vector analysis tool. Using this framework to rank and evaluate the risks of invasion, managers can now rationally prioritize and target the most important vectors. This frees them to allocate resources more effectively as they struggle to head off the invasion of non-native species.



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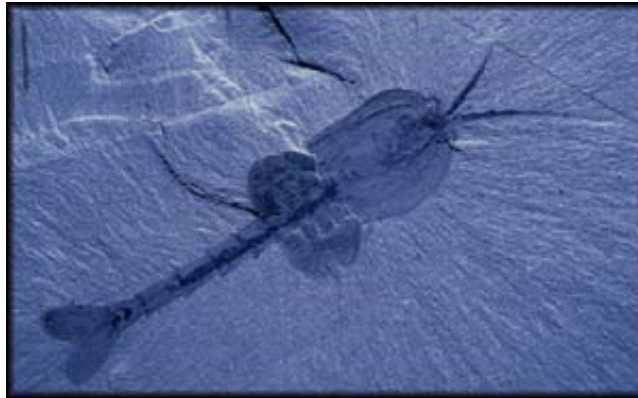
Reimagining the Yin  
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The fossils of the Middle Cambrian Burgess Shale (505 million years ago) illustrate the many body plan architectures that evolved rapidly during the Cambrian Metazoan Diversification. Shown is the arthropod *Waptia*. These fossils were collected by Charles Walcott, 4<sup>th</sup> Secretary of the Smithsonian Institution, and currently in the NMNH collections.

## Reimagining the Yin and Yang of Evolutionary Biology

### Additional Resources

Science Magazine, Vol. 311, Issue 5762, Pages 737-869.

Natural History Museum Website  
<http://www.mnh.si.edu/>

Can one really be rigid and flexible at the same time? Much as a gymnast stands unbending before the music starts, yet contains within her sinew the flexibility to achieve amazing feats, so too, locked within the genes of her every cell is a similar rigid certainty mixed with amazing flexibility.

A Smithsonian evolutionary biologist has found a new way to model these seemingly contradictory elements of evolution; its unmatched flexibility in the face of environmental change and the rock-solid stability of the basic animal forms, or phyla, it produced over half a billion years ago in the Early Cambrian period. He turned, with startling success, to the language of computers and networking for inspiration.

Smithsonian National Museum of Natural History Paleobiologist Douglas Erwin, and Eric Davidson, a developmental biologist at the California Institute of Technology, share their work in the current edition of the magazine *Science*. They provide a blueprint outlining why the basic architecture of major animal groups, such as how hearts or eyes are formed, has been maintained for eons. Yet, evolution has continued to produce unique details and adaptations that allow myriad life

forms to flourish in ever changing environments.

Their answer focuses on explaining the interplay of developmental gene regulatory networks, or GRNs, that control the embryonic development of body form. At the hub of the GRN network are kernels, genetic structures that, due to their developmental role and the wiring of the genes within them, are most impervious to change. Kernels determine such fundamental structural issues as where appendages or organs should form in the developing embryo. They are vastly interconnected so that a change in a kernel will lead to developmental catastrophe and the destruction of an embryo.

Because of the kernel's inherent resistance to genetic change, the basic body structures by which phyla are defined have persisted for millions of years.

At the other end of the network, less chemically restrained by interdependent relationships and cross wiring, are the differentiation gene batteries (DGBs). DGBs possess much more freedom to mutate without destructive effects. DGBs control such developments as digestive



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enzymes which can allow some primates to subsist entirely on a diet of leaves. Random genetic changes in DGBs are far less likely to produce inviable embryos, and serve as the foundation for most evolutionary change. These descendants and their DGB induced adaptations are then able to test their genetic worthiness in the environment.

Because mutations at the DGB level don't ripple through the network like kernel changes, and thus don't destroy the embryo, they are able to form the basis of species level evolution.

Their entire GRN model includes "kernels", evolutionarily inflexible

subcircuits that perform essential functions in building given body parts; "plug-ins," small subcircuits that are used over and over for diverse developmental purposes; switches, that act as gatekeepers for developmental subcircuits; and the aforementioned differentiation gene batteries.

The power of this model is that it suggests a hierarchical model of evolution, and one that evolves through time. The scaffolding of animal body plans is established early by the kernels of the GRN, but evolutionary flexibility is accommodated through changes at other levels of the genetic network infrastructure.





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Reimagining the Yin and Yang of Evolutionary Biology



Deciphering the Story of a Rejected Star



From Sputnik to Satellite Phones, Space Race Technology Mirrors Its Makers



An optical photo of the outcast star (marked by the arrow). The star, having been ejected from the vicinity of the Milky Way's central black hole, is already in the distant outskirts of our galaxy which it will leave forever. The image (courtesy of the Sloan Digital Sky Survey) shows an area of sky about 1/50th the size of the full Moon.

## Deciphering the Story of A Rejected Star

### Reference

C. Fuentes et al., "The Hypervelocity Star SUDSS J090745.0+024507 is Variable," *the Astrophysical Journal Letters*, 2006, 636, L37.

### Additional Resources

Smithsonian Astrophysical Observatory Web Site  
<http://www.cfa.harvard.edu/saohome.html>

Multiple Mirror Telescope Observatory Web Site  
<http://www.mmt.org/>

Last February, a team of Smithsonian Astrophysical Observatory (SAO) astronomers reported discovering the first known stellar "outcast" - a star in the outer halo of our Milky Way galaxy that appears to have been ejected from the center of the galaxy, that is, from the immediate neighborhood of the massive black hole that resides there. Theoretical reasoning indicates that the star was ejected when the binary companion it orbited was disrupted by the black hole. The star is now racing outward from the galaxy at a speed of about 700 kilometers per second, but, since the original discovery could not accurately ascertain the distance to the star, the time of this ejection was also very uncertain. The discovery of such a high-velocity star lent additional credibility to the picture of a massive black hole at the galactic center, to calculations of how such black holes might interact with their environments, and not least to an increasingly precise description of the outer halo of our home galaxy. It was therefore very important to try to obtain a precise estimate of the star's current distance and character.

A team of eight SAO astronomers led by Cesar Fuentes monitored this star over a

period of several months last year using the MMT 6.5 meter telescope and the 1.2 meter telescope at the Fred L. Whipple Observatory on Mt. Hopkins, AZ. They found that the star varies periodically in brightness, in a manner that strongly suggests it is a pulsating main sequence star about three solar masses in size (main sequence stars, like the Sun, are stars that are fusing their hydrogen into helium in a comparatively long-lived phase of their lives). With this identification, the scientists could closely estimate the star's intrinsic brightness and then, from its apparent brightness, infer its distance: 231,000 light-years from the galactic center, plus or minus a few percent. The results imply that the age of the star is less than about 350 million years old, and that it must have been ejected less than about one hundred million years ago. Besides categorizing this outcast star and determining its age, distance, and ejection time, the new results also provide the evidence that, at a time when dinosaurs still ruled the Earth, the center of our galaxy was not old and dying, but rather an active region where there were newly born stars, some as close as about 30 light-years from the black hole monster itself.



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From Sputnik to Satellite Phones, Space Race Technology Mirrors Its Makers



John Glenn's Friendship 7 Project Mercury capsule in the National Air and Space Museum

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### Additional Resources

The Space Race exhibition at the National Air and Space Museum

Listen to the first man-made voice from outer space; telemetry from Sputnik I as it orbited the Earth in October 1957.

Preorder the book from Amazon.com

Just like the babyboomers who came of age as the world's super powers struggled for supremacy in space, the Space Age is entering Middle Age.

The Space Age still evokes visions of spectacular achievements that are just over the horizon. However, it was actually ushered in almost half a century ago by the launching of the Sputnik satellite on October 4, 1957. Therefore, many of the Age's miraculous tomorrows are really yesterdays. Perhaps that is why the publication of a new book taking a historical, technical and social look at space artifacts is so timely.

*Showcasing Space*, edited by Martin Collins, National Air and Space Museum (NASM) curator, and Douglas Millard, Associate Curator, Space Technology, at the Science Museum, London, England, is part of the series *Artefact: Studies in the History of Science and Technology*. The book looks at some of our greatest technological achievements and asks questions similar to those of a cultural anthropologist. Just as an ornate Roman chariot from the first century BCE provides insight into its milieu, so does John Glenn's Friendship 7 Mercury capsule.

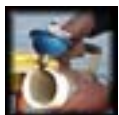
Artifacts covered in this volume are international in scope and include the

German Astris rocket, the British Black Arrow R4 rocket, the Australian Woomera Test Range, Soviet personal diaries, and the multinational Iridium satellite-telephone communications satellite.

What do these objects say about the cultures that produced them? What are the differences and commonalities across technologies, institutions, professional communities, projects and geographical contexts? Is there inherent power in the physical object that is lost in a simple photograph or set of blueprints? These are just some of the questions answered in essays by seven contributors, most of them museum curators.

The volume, based in part, on a seminar organized in 2002, includes essays by NASM curators Collins (who also wrote the introduction), Cathleen Lewis, and David DeVorkin, museum specialist Brian Nicklas, and former Lindbergh Chair, Philip Scranton.

The overarching purpose of the multi-volume *Artefact* series is "to explore the overlapping interests of museums and historians of science and technology in understanding artifacts, as well as presenting that understanding to scholarly and general publics."



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