

Paper Engineering



Smithsonian Institution Libraries

Paper Engineering: Fold, Pull, Pop & Turn

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Curator

Stephen Van Dyk, Cooper-Hewitt, National Design Museum Library

With assistance from

Elizabeth Broman, Cooper-Hewitt, National Design Museum Library

Ellen G. K. Rubin

Ann Montanaro, Director, The Movable Book Society

Exhibition design, editing, and production

Office of Exhibits Central, Smithsonian Institution

Exhibition brochure design

Elizabeth Periale

Dedicated to Pam Stiles (1935-2005) and Waldo J. Hunt (1920-2009)
who loved pop-up and movable books

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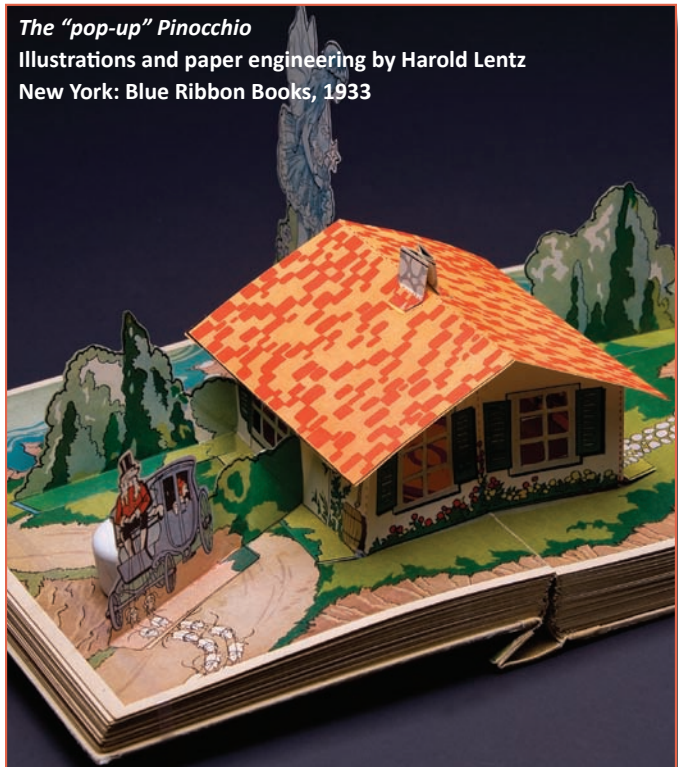
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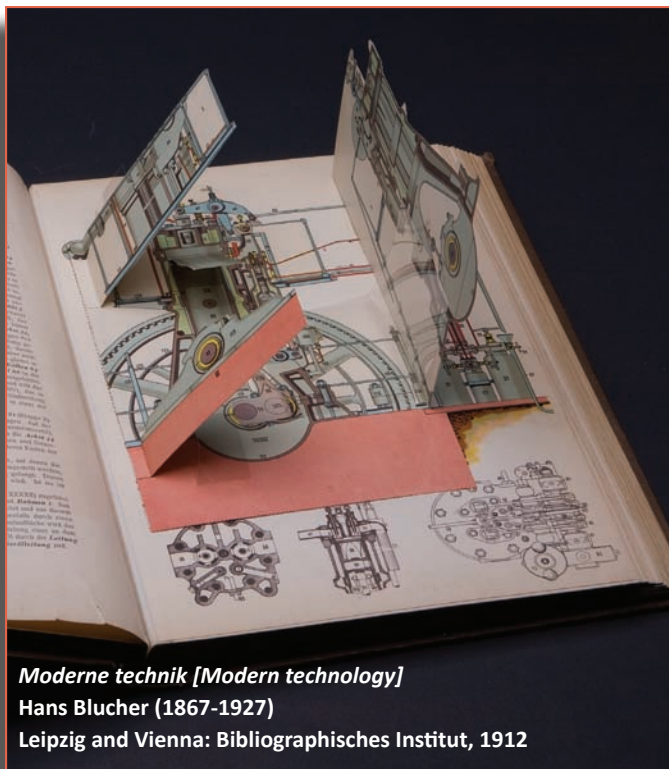
Pop-up and movable books have been delighting and engaging readers and non-readers, young and old alike, for nearly 800 years. Using inventive ways to fold paper and create movement, pop-up artists and paper engineers transform the printed page from two-dimensional forms to three-dimensional experiences.

Movables have mechanisms such as flaps, pull tabs, and wheels (volvelles) that cause movement on the page surface. Pop-ups employ various folding devices that cause figures to lift, pop up, rise and unfold, or unfold and extend when a page is opened. Despite changes in technologies, materials, and mechanisms, contemporary books, like their predecessors, are still assembled

by hand and share some of the same construction principles. And although we may associate pop-ups and movable books with children, adults were the original audience for what was anything but child's play.

Paper Engineering: Fold, Pull, Pop & Turn presents more than 50 examples of action-packed constructions and inspired works of art spanning 500 years.

We hope exhibition visitors will experience these rarely seen treasures as their creators intended—as remarkable works that calculate, educate, entertain, and amaze.



Moderne techniek [Modern technology]

Hans Blucher (1867-1927)

Leipzig and Vienna: Bibliographisches Institut, 1912

Moving from a static printed page to a three-dimensional mechanical book changes the dynamic between reader, words, and illustrations. The relationship becomes more interactive, more tactile, and, well, more dynamic. We depend on our senses to absorb and process information. Introducing the sense of touch to the mix, not to mention the element of surprise, expands what is primarily a visual experience. Adding movement contributes yet another way for readers and non-readers to learn and enjoy. Hands-on and kinetic, movable and pop-up books combine hands and eyes, action and reaction, discovery and wonder.

Useful Tools

The story of movable and pop-up construction begins within the walls of a medieval monastery. The earliest books with movable parts recorded and communicated information and also calculated data. Illustrated volvelles or wheels were super-imposed on the surface of a page, turning to align data to calculate the position of the stars, church calendar, astrological signs, and the like. It is thought that the Benedictine monk Matthew Paris employed volvelles to determine ecclesiastical dates as early as the 13th century, as did the Catalan mystic and poet Ramon Llull shortly thereafter to explain his theory of spirituality and truth.



The invention and expanded use of movable press type, which began in the 1450s, coupled with the growth of scientific knowledge published in the centuries that followed, resulted in the creation of some of the most magnificent volvelles of all time. Among these, with beautifully embellished wheels to calculate astrological and astronomical data, are Peter Apian's *Astronomicum caesareum* (1540), Johann Schöner's *Opera mathematica* (1550), and Leonhard Thurneysser's *Dess menchen circkel und lauff* (1575-1583).

In more modern times, wheels, placed within texts or as stand-alone objects, have been used to count calories, match paint colors, identify bird species, score contract bridge, and present fun facts about American presidents.

Enhancing Discovery and Learning

How Better to Explain

From the 16th century onward, the publishing of illustrated works grew rapidly. Advances in printing made books more accessible, and scholars demanded up-to-date recorded knowledge. Movable and pop-up books were used to demonstrate visually complex systems, particularly relating to medicine, mathematics, and technology. How better to explain the intricate layering and position of organs in the human body than by creating a series of hinged flaps that



Astronomicum caesareum [The emperor's astronomy]
Peter Apian
Ingolstadt, Germany, 1540
On loan from Mr. and Mrs. Robert Gordon and the Adler
Planetarium

when opened reveal, for example, the chest cavity, as in David Pelham's *The human body* (1983), or the multiple valves and muscles of the heart in René Descartes' *De homine [On Man]* (1662).

To illustrate the theorems and proofs of the Greek mathematician Euclid, three-dimensional cubes, squares, and triangles rise from the page in *The Elements of geometrie . . .* (1570) [page 5]. The complex parts of cars, steam-powered locomotives, ships, and other machines seen in *Moderne technik* (1912) [page 4] are revealed and explained layer by detailed layer. Ron Van der Meer's *Inside the personal computer* (1984) [page 20] provides a basic introduction to the PC, with a three-dimensional prototype that pops up off the page. And in *Observations on the theory and practice of landscape gardening* (1803), English landscape designer Sir Humphry Repton cleverly uses flaps to create "before" and "after" views that help prospective clients visualize the transformation of their gardens.

Teaching the Basics

Movable and pop-up books teach in clever ways, making the learning experience more effective, interactive, and memorable. In late-18th-century England and America, an educated middle-class population emerged from the Industrial Revolution. They recognized the importance of childhood and had disposable income to purchase books to educate their



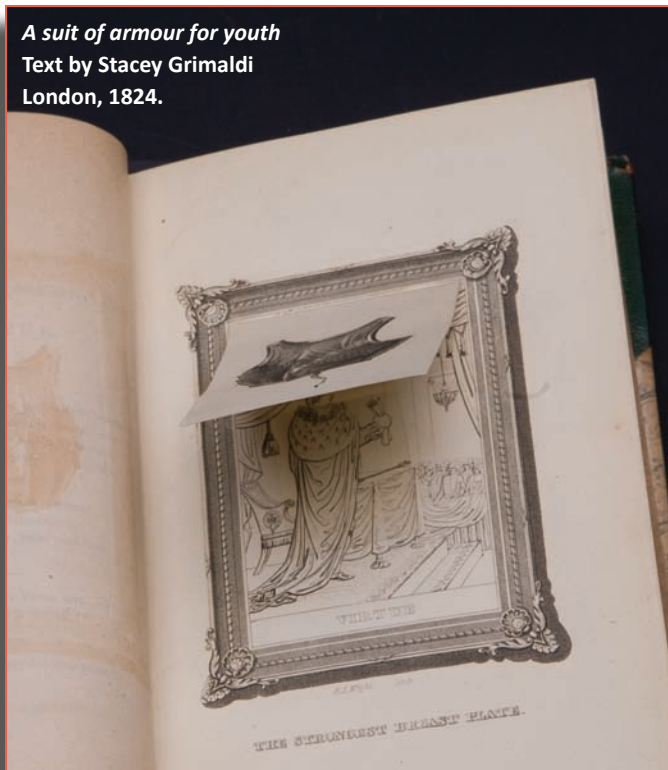
sons and daughters. As a result, publishers developed books specifically geared to teach religion and manners, picture books that could be read aloud to children, illustrated arithmetic and ABC primers, as well as stories for pure entertainment.

London bookseller Robert Sayer created some of the earliest movables in the 1760s. Called “metamorphoses,” “turned-ups,” or “harlequinades,” they consisted of a series of flaps that when lifted revealed an illustrated moral tale featuring a harlequin figure. In the 1820s, English miniature painter William Grimaldi with his son Stacey developed a series of flap books to teach etiquette. In his *A suit of armour for youth* (1824), about the virtues of being a gentleman, the

answers to riddles and popular sayings appear when the flap is raised. Movable and pop-up versions of books that offer instruction on religion and cultural traditions remain popular. M. Coerezza’s *Catechetical scenes: the law of love* (1960) and Singer’s *The children’s Haggadah* (1933) colorfully and dramatically relate Bible stories.

Learning through discovery injects some fun into the three “Rs” as children uncover letters in Robert Crowther’s *The most amazing hide and seek alphabet book* (1977), or are introduced to counting numbers in Renée Jablow’s *Richard Scarry’s pop-up numbers* (1996). Movable and pop-up books offer enticements to learn

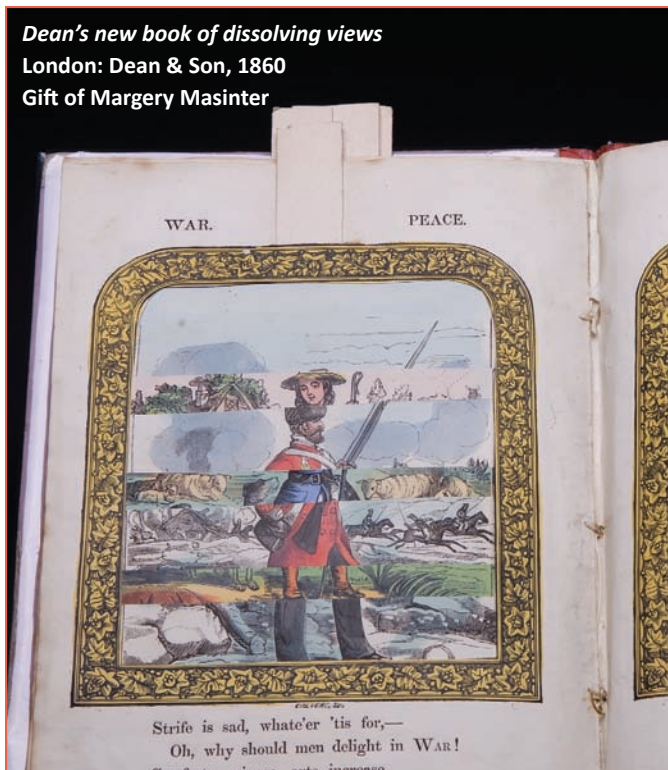
A suit of armour for youth
Text by Stacey Grimaldi
London, 1824.



when they present a chance to interact by pulling tabs, turning wheels, and becoming part of the action. For young readers, visuals can easily illustrate abstract concepts such as the opposites of night and day, summer and winter. Contrasting images are revealed when a tab is pulled in *Dean's new book of dissolving views* (1860). Following a story read aloud while illustrations move and lift off the page makes learning enjoyable and interactive. *The nutcracker: a pop-up* (1992), with paper engineering by Paul Wilgress, and the pop-up version of Eric Carle's *The honeybee and the robber* (1981) incorporate movable and pop-up mechanisms within the narrative.

Visualizing the World Around Us

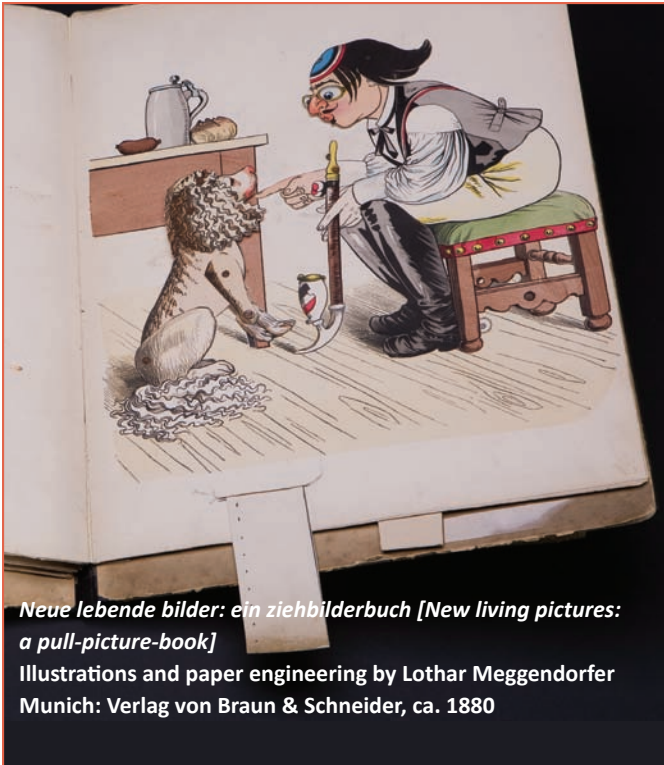
Movable and pop-up books also help us document, explore, and experience the wonders of our built and natural environment. In paper engineer Ib Penick's *Those fabulous flying machines* (1985) [page 19] intricately drawn and constructed pop-up images of aircraft seem to hover over the page. In Vic Duppa-Whyte's *The space shuttle action book* (1983), we can visualize the structure and detailed parts of each vessel. The natural world comes alive when a larger-than-life, yet anatomically precise image of a bee unfolds to 360 degrees in David Hawcock's *Bee* (1994). Readers encounter the stages



of development of dinosaurs in the National Geographic Society's action-packed *Creatures of long ago: dinosaurs* (1988); experience the color, movement, and depth of the jungle in *Amazing monkeys* (1985); and explore the sights and sounds of birds in their natural habitats in *Birdscapes* (2008).

The early accordion book *Thames tunnel* (1843), recent pop-up surveys of the works of architects Frank Lloyd Wright (2002) and Frank Gehry (2007), and Keith Moseley's *La maison victorienne . . .* (1999) all document the dynamic forms associated with buildings, monuments, and bridges. Other movables and pop-ups, such as *Peter and Wendy see the New York World's Fair* (1963), commemorate historic events, while Pat Paris' *The first Noel: a holiday pop-up book* (1998) and others celebrate seasonal festivities.

Movable and pop-up books provide new perspectives and enhance our experience of everyday activities and surroundings. Munich artist Lothar Meggendorfer was the creator of early complex pull-tab mechanisms that caused multiple movements within one scene. In his *Neue lebende bilder* (1880), a butcher chops meat, a girl draws water from a well, a man teaches his dog a new trick, and two women wash clothes after pull-tabs initiate the action. Meggendorfer also created colorful stage-like panoramas

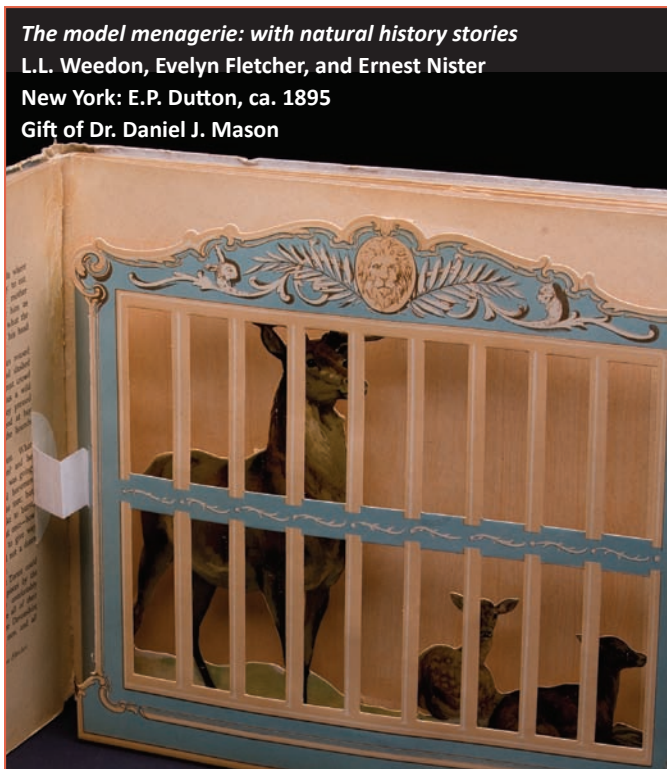


Neue lebende bilder: ein ziehbilderbuch [New living pictures: a pull-picture-book]

Illustrations and paper engineering by Lothar Meggendorfer
Munich: Verlag von Braun & Schneider, ca. 1880

in *Im stadtpark [The city park]* (1887) and illustrated his books with whimsical yet familiar characters that greatly appealed to young readers. We get a bird's-eye view of the inside of a 1950s service station when the carousel book *Garage* (1950) is fully unfolded. As the central page of Bruce Foster's *Wow!: The pop-up book of sports* (2009) is opened, we're suddenly at center court with the net lifting off the surface and a tennis ball zooming directly at us.

Stories that feature children relating to the world are the focus of many movable and pop-up books. Children play together in Raphael Tuck & Sons' *Jolly companions* (1896) and participate in the adventures of the Jolly Jump-Ups family, a series of stage-set pop-ups created by Geraldine Clyne (1930s-1960s). Ernest Nister, a Nuremberg publisher and innovator of pop-up and movable mechanisms, regularly features well-dressed Victorian children in stories like his *Circling surprises* (1901), a revolving wheel slat book. A visit to the zoo becomes an exciting adventure in Nister's *The model menagerie* (1895), when caged animals magically lift into three-dimensional forms as each page is turned. Children enjoy a trip to the circus in paper engineer Julian Wehr's *Animated circus book* (1943), in which his pull-tab system allows circus animals and performers to move across a page in all directions.



For the Fun of It

Novelty Books / Toys and Games

Most movable and pop-up books were created to entertain, and many of the great innovators designed books that still amuse us. In the late 18th century, German engraver Martin Engelbrecht created illustrated and intricately cut paper cards that, when placed behind each other at intervals, created tunnel-like works with dramatic perspective views. His peep-shows were popular parlor amusements and inspired tunnel books in the centuries that followed. In the 19th century, advances in printing and paper production helped spur the growth of

affordable and accessible printed novelties, board games, toys, juvenile story books, and movables and pop-ups.

The interactive elements of movables and pop-ups are much like playing a game. The amusement and delight of discovery and the ability to lift and pull mechanisms are all opportunities for the reader to participate. Lifting a flap or pulling a tab in Bennett Cerf's *Pop-up riddles* (1967) or Tor Lokvig's *What do you get?* (1960s) provides answers to riddles and questions.



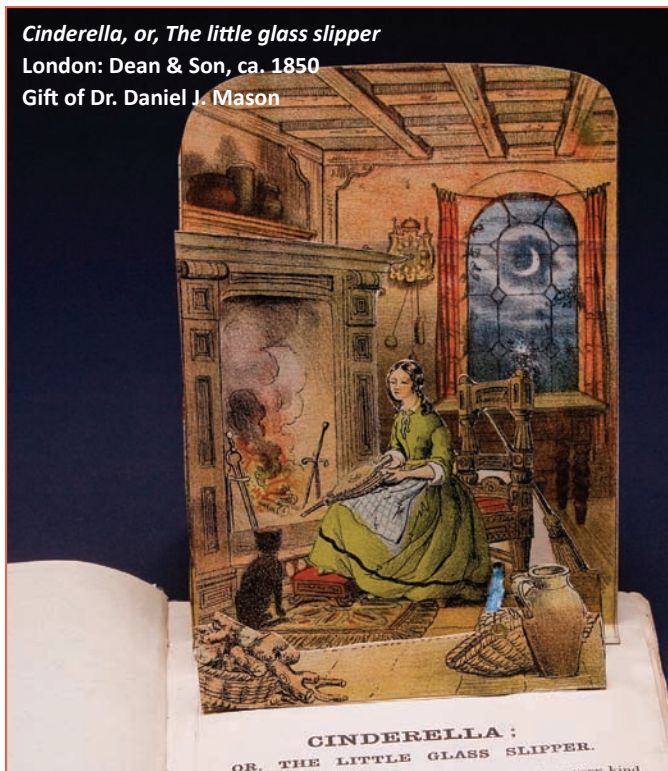
Garden scene
Martin Engelbrecht
Augsburg, Germany, ca. 1740

You can discover all five senses in Tony Sarg's *Surprise book* (1941), and find the hidden numbers in Paul Zelinsky's *Knick-knack paddywack!* (2002) nursery rhyme book.

Fairy Tales

A longstanding tradition and popular theme of movables and pop-ups is the re-telling of fairy tales and fables. As early as the 1850s, London publisher Dean & Son, considered one of the pioneering innovators of books with movable parts such as the pull tab and the dissolving image, developed movable editions of *Aladdin*, *Cinderella*, and *Little Red Riding Hood*. In Dean's *Cinderella, or, The little glass slipper* (1850), die-cut images lift from the surface of the page when a ribbon is pulled.

The McLoughlin Brothers, a New York-based publisher of board games and some of America's earliest pop-up books, retell the story of Aladdin. In their pantomime book, *Aladdin, or, The wonderful lamp* (1880) [page 22], movable characters appear in a stage-like setting. From 1932-1935, The Blue Ribbon Publishing Company of New York produced a series of colorful, large-type fairy tale pop-up books under the direction of paper engineer Harold B. Lentz. These included *The "pop-up" Mother Goose*, *Jack the giant killer*, *Puss in Boots*, and *Sleeping Beauty*. The *Pop-up Pinocchio* (1932)



[page 3], an abbreviated version of the traditional Italian folk story, featured several distinctive v-fold and box and cylinder constructions: one with Pinocchio reading, another of his house, and yet another of a large whale.

Mario Zampini, an Italian illustrator and stage designer, uses a series of theatrical sets in a carousel book to recreate the story of *Ali Baba and the 40 thieves* [*Ali Baba e i 40 ladroni*] (1950). New interpretations of fairy tales and traditional folk stories remain popular and continue to inspire paper engineers and pop-up artists today.

Adventure and Fantasy Stories



Ali Baba e i 40 ladroni [*Ali Baba and the 40 thieves*]

Mario Zampini and Raimondo Centurione

Milan: Hoepli editore, ca. 1950

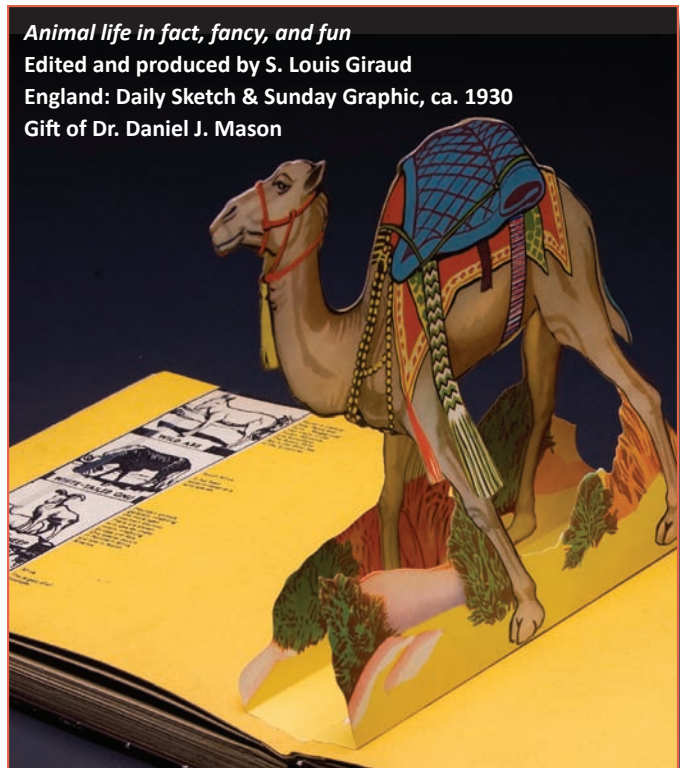
Gift of Roma and David Korris

Adventure and fantasy stories for children were first published in the 19th century. Many of the most popular of these were issued in several subsequent editions and later in pop-up and/or movable versions—most notably *Peter Rabbit*, *Winnie-the-Pooh*, and Charles Kingsley’s 1920 novel *Water-babies*. S. Louis Giraud, publications manager for London’s *Daily Express*, in collaboration with inventor Theodore Brown, created a true “pop-up” book that automatically unfolds to become a three-dimensional free-standing figure viewable from all sides.

These new pop-up constructions appeared in Giraud's adventure story *Animal life in fact, fancy and fun* (1930).

In the 1950s-1960s, Vojtěch Kubašta, an Austrian-born paper engineer and illustrator working in Czechoslovakia, created a series of pop-up adventure and fantasy stories combining bold folk art-style imagery, distinctive colors, and innovative cut and folded paper styles. Some of his large-scale constructions of this period include *Marco Polo* (1962), *The tournament* (1950s), and *Ricky the Rabbit* (1961). Later and contemporary pop-up fantasy and adventure books include James Roger Diaz's *Alice's adventures in Wonderland* (1980), Jan Pieńkowski's *Robot* (1981), Robert Sabuda's *The wonderful wizard of Oz* (2000), and Sam Ita's *Moby Dick: a pop-up book* (2007).

Movable and pop-up books have also reflected the influence of popular culture and the mass media. In the 1930s, The Blue Ribbon Publishing Company and Pleasure Books introduced a series of small, colorful, comics-inspired pop-up books that included *Dick Tracy, capture of Boris Arson* (1935) and *Terry and the Pirates in "Shipwrecked"* (1935) [page 16]. Later pop-ups featured characters from television series such as *Hopalong Cassidy lends a helping hand* (1950) and *Sesame Street* (1970s-



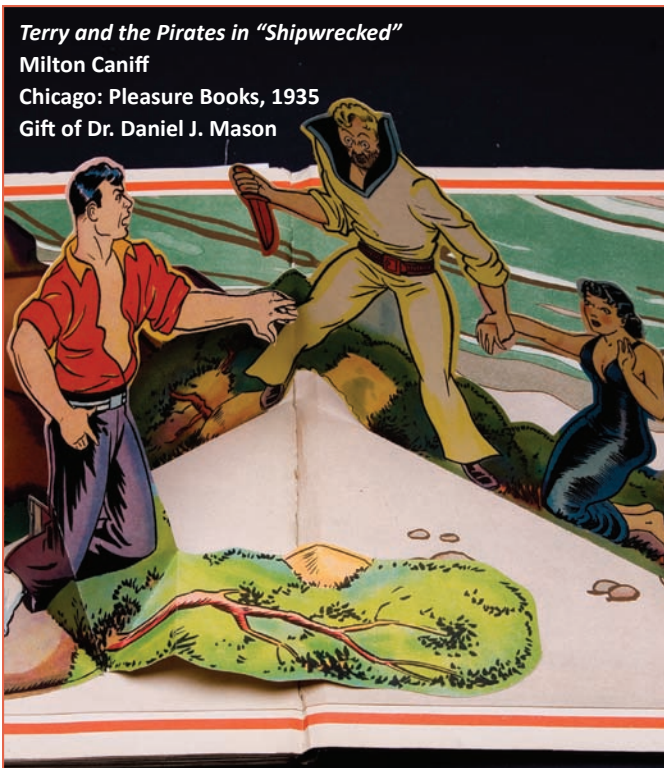
1980s). More recently, our fascination with outer space is interpreted by Chuck Murphy's *Star Trek*-themed *These are the voyages* (1996) and Matthew Reinhart's action-packed *Star Wars: a pop-up guide to the galaxy* (2007). Pop-ups based on Disney's animated films remain perennial favorites.

Fantastic Forms

For centuries, designers and paper engineers have manipulated and folded paper in innovative and interesting ways to create sculptural forms within pop-ups. When unfolded, panoramas, peep-shows, and carousels are transformed into rectangular tunnels, box, and circular paper

sculptures. In other books, sculptural forms such as cylinders, globes, squares, and the like pop up from the surface when a page is turned.

In the 1960s, American businessman Waldo Hunt, inspired by the sculptural cut-paper forms and illustrations of Vojtěch Kubašta, was instrumental in reviving the manufacture of pop-up and movable books. Hunt founded Intervisual Communications in the 1970s to produce pop-up books exclusively. He promoted paper engineers such as Jan Pieńkowski, Tor Lokvig, David Pelham, Marcin Stajewski, James Roger Diaz, Keith Moseley, John Strejan, Ib Penick, David Carter,



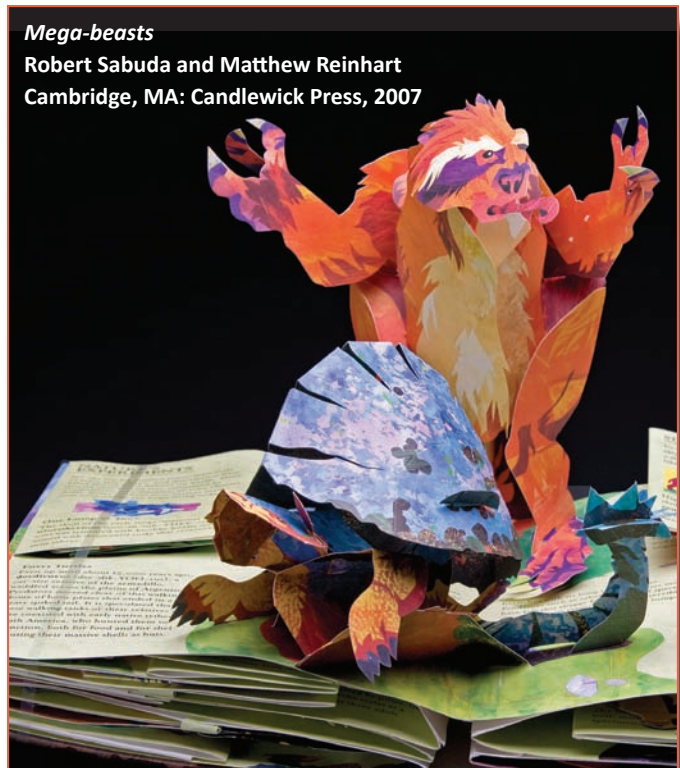
Terry and the Pirates in "Shipwrecked"
Milton Caniff
Chicago: Pleasure Books, 1935
Gift of Dr. Daniel J. Mason

and Ron Van der Meer, among others. They created hundreds of popular movables and pop-ups, many with new and innovative construction forms, during the 1970s-1980s. These paper engineers, along with others working later into the 1990s and beyond, benefited from advancements in computer-aided design, laser printers, and cutting devices that made the use of intricate folds and complex paper parts possible for mass market production.

Contemporary paper engineers employ diverse and complex mechanisms on each page, adding greatly to their books' interactive qualities. *In the beginning* (2008) by Fischer/Foster and *Mega-beasts* (2007) by Sabuda/Reinhart are wonderful examples. Designers challenge the limits of the three-dimensional form by creating intricate constructions that dramatically emerge from the page surface, such as *Bible stories from the Old Testament . . .* (1991) by Christos Kondeatis.

Others cleverly conceal pull mechanisms over multiple images to create movement—*Gallop!* (2007) by Rufus Seder—or innovative cut-paper folds to reveal pop-up figures—*Numbers* (2000) by Kees Moerbeek.

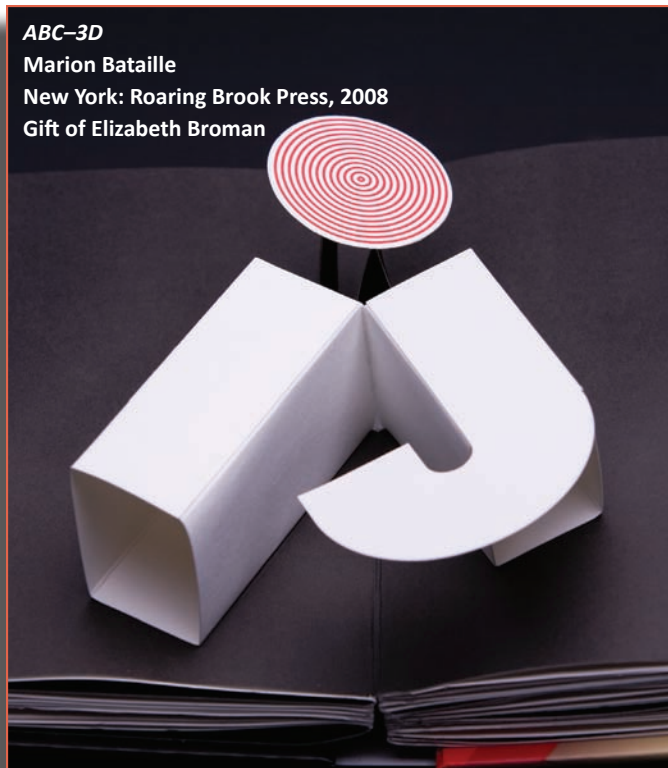
And yet, in still other pop-ups, the simple, dynamic quality of the cut paper forms and mechanisms dominate, enhancing the appearance of the book as a sculptural work of art:



Marion Bataille's *ABC-3D* (2008) [page 17] and David Carter's *One red dot* (2004) [cover].

Today's imaginative paper engineers continue to explore and to innovate new ways to fold paper, devise complex pull tabs that create movement, design intricate three-dimensional pop-up forms, and use cut paper, string, and other mechanisms to make figures magically twist and turn. The possibilities seem endless. Each year hundreds of action-packed, beautifully crafted works pop up to inspire, awe, educate, and heighten our love and enjoyment of books.

Whether early or contemporary, movables and pop-ups dramatically offer children and adults the opportunity to discover and experience the joy of books in delightful and remarkable ways.



What Makes Pop-ups Pop?

The answer lies in a variety of methods of cutting and folding, and in mechanisms hidden behind and underneath the page. The construction methods are endless, but they can be divided into four categories: movable parts that lie flat, images that pop up, books that fold, and fantastic forms that use multiple mechanisms.

Movables: Elements lie flat on the page—but they don't lie still. These books fall into a few basic construction types: volvelles or wheels, flap books, and pull tabs.

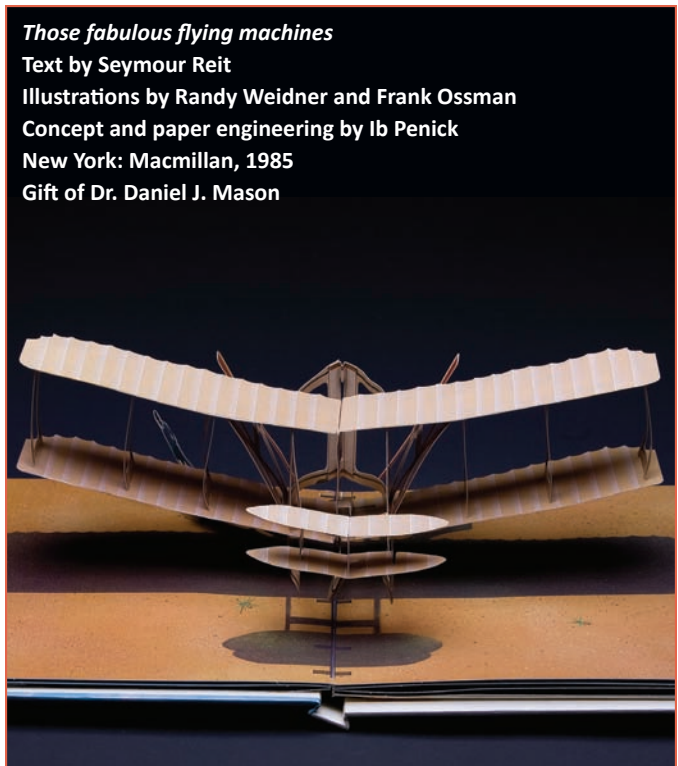
Pop-ups: Three-dimensional figures spring to life in pop-up books, rising from the surface of the page. Four basic construction techniques are used in creating pop-ups: stage set, v-fold, box and cylinder, and floating layers. In each of these methods, cleverly folded paper cut-outs unfold when the book is opened and a page is turned.

Folding mechanisms: Some books are designed to open like an accordion, or to fan out and form a circle. Books that unfold can take a variety of forms, which are called leporellos, carousels, and tunnel books or peep-shows.

Multiple constructions: Contemporary paper engineers don't confine themselves to a single method. By exploring combinations of construction techniques, they find new ways to amuse, teach, and surprise us. Paper is no longer the only material used. Plastic, string, mirrors, and sticks are now part of the pop-up mix.

Pop-up Elements

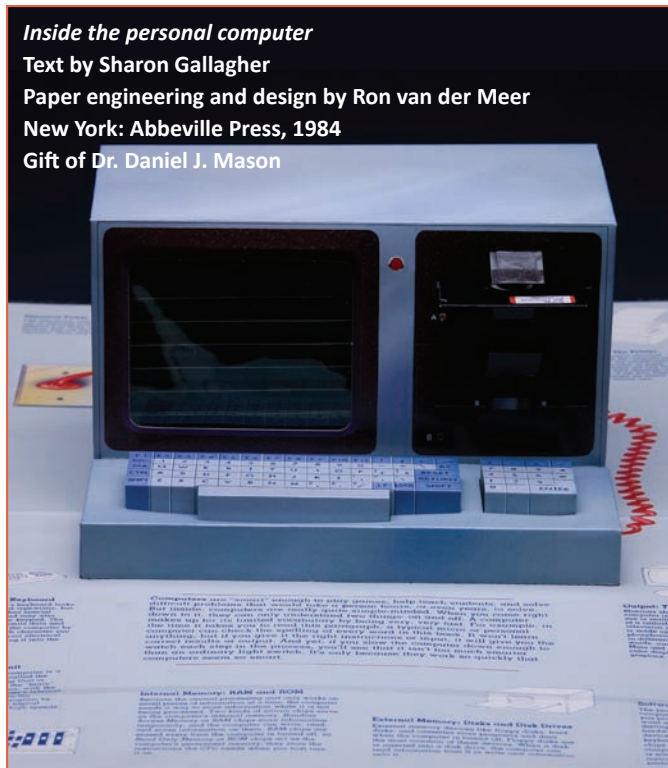
Box and cylinder: A box-like cube or rounded cylinder rises from the center of the page spread as the book is opened.



Carousel: In a carousel book, the covers are folded back and opened to a complete circle and secured with string, ribbon, snaps, or Velcro. This creates a series of three-dimensional dramatic scenes that tell a story or sometimes present a set of little rooms to play in.

Dissolving images and slats: An illustration changes into a completely different scene at the pull of a tab. The dissolving effect, or transformation, is achieved by the pictures being printed on horizontal, vertical, or circular sections that slide over each other. These are sometimes also called metamorphoses.

Flap or lift the flap: One of the simplest forms in a movable. When a piece of illustrated paper, attached to the base page at a single point, is lifted, a hidden illustration, message, or movable is revealed. Harlequinades or pantomime books, in which each lifted flap changes the picture or reveals a new twist in the plot, are a form of flap mechanism. Flaps may be cut into the shape of the illustration.



Floating layers or platforms: This mechanism is best understood when seen from the side. Hinged multi-tier paper supports lift an illustration off the page, creating the illusion that it is floating over the surface.

Harlequinades and metamorphoses: A series of flaps that when lifted reveal a new picture or message. Also, a booklet with illustrations split in the center, laterally. When the illustration is folded up or down, or the series of flaps are lifted, a new picture or message underneath is revealed. Some 18th-century flap books were inspired by the theater. Often featuring the comic character Harlequin, these were called harlequinades or pantomime books.

Leporello: An accordion book formed of one long sheet of folded paper that stretches out in a zigzag or concertina shape. It is named after Leporello, the servant in the opera *Don Giovanni*, who carries such a book to record the endless list of Giovanni's romantic conquests.

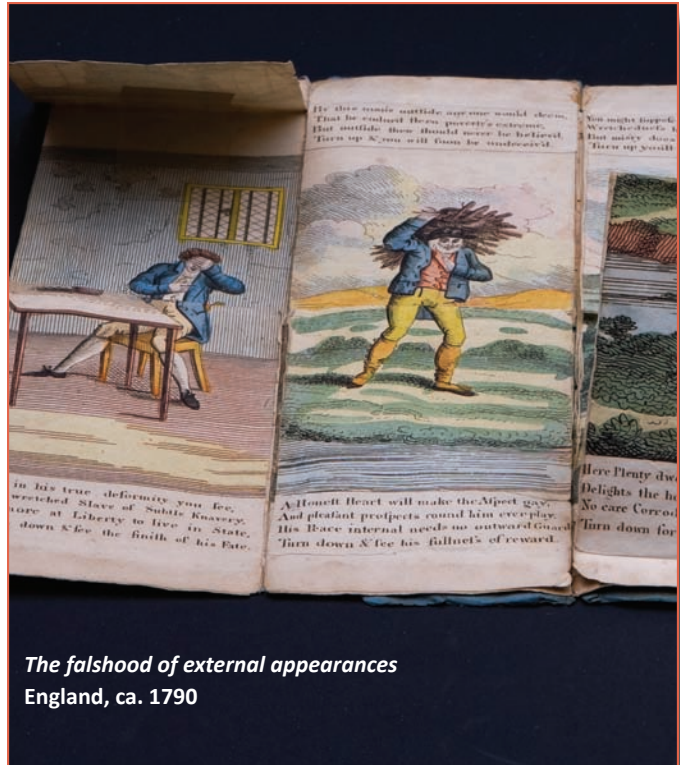
Paper engineer: An artist who uses various techniques (e.g., cutting, folding, and/or gluing) to make paper illustrations move or pop up. The paper engineer may or may not also be the illustrator.

Pull-tab: A sliding paper tab, ribbon, or string is pulled, pushed, and maneuvered to reveal a new image. The tabs can also activate a pop-up. A figure goes into action when you pull or slide a tab: dancers sway, dogs sit up and beg, robots move.

Stage set or multiple layers: A book becomes a theater set when it is opened to a 90-degree angle. This was one of the first constructions to be used for pop-up books and particularly suited to display interior scenes.

Tunnel book or peep-show: A series of cut-paper panels are placed or hinged one behind the other, creating the illusion of depth and perspective, like looking into a tunnel. The term "peep-show" is derived from 18th- and 19th-century itinerant showmen who carried these mechanisms from place to place and charged a fee for viewing.

V-fold: This versatile form is what most people think of when they hear the term "pop-up." The pop-up element is attached to facing pages and unfolds from the center of the page when the book is open; it collapses into itself when the book is closed.



The falshood of external appearances
England, ca. 1790

Volvelle or wheel: An illustrated paper disc or circle is attached to a page using string, paper, or grommets and revolves around a central pivot. As the reader turns the wheel, the discs align images and information. The disc can be perforated to reveal designs underneath. The word volvelle is derived from the Latin verb, *volvere*, to turn.

Waterfall: An embellishment of the pull-tab activated flap, several flaps open onto each other sequentially as the single tab is pulled in the opposite direction.

Learn More

Print Resources

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Aladdin, or, The wonderful lamp
New York: McLoughlin Brothers, ca. 1880
Gift of Ellen Liman

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Online Resources

A concise history of pop-up books by Ann Montanaro:

www.libraries.rutgers.edu/rul/libscua/montanar/p-intro.htm

The Movable Book Society:

www.movablebooksociety.org

Pop-up and movable books: a tour through their history by University of North Texas Rare Book and Texana Collections:

www.library.unt.edu/rarebooks/exhibits/popup2/default.htm

Pop goes the page by University of Virginia Brenda Forman Collection:

www2.lib.virginia.edu/exhibits/popup/index.html

The pop-up lady by Ellen Rubin:

www.popuplady.com

Read and comment on our *Fold, Pull, Pop & Turn* blog:
smithsonianlibraries.si.edu/foldpullpopturn/



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