PLACES & SPACES &
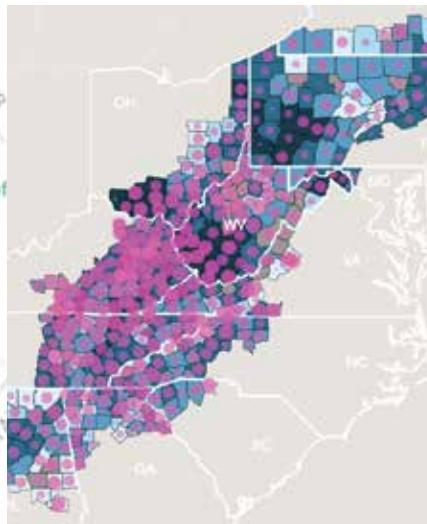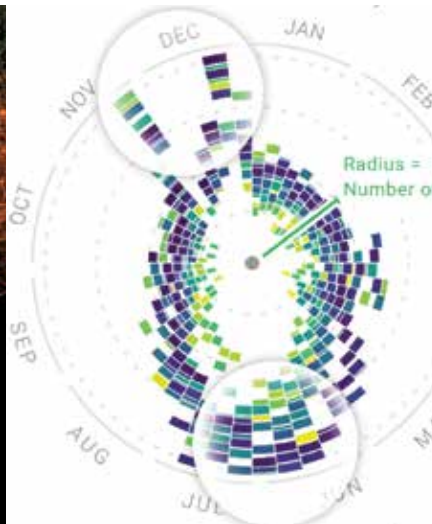
MAPPING SCIENCE

ENSURING OUR WELL-BEING

Letter from the Curators

This year we said "goodbye" to our longtime home in the Herman B Wells Library at Indiana University and headed a mile down the street to Indiana University's beautiful new Luddy Hall. Leaving a place that you've been at for so many years is always bittersweet. However, the larger space, state-of-the-art resources, and increased possibilities for collaboration that Luddy Hall provides has made the move an exciting one for all of us. Indeed, it did not take long for *Places & Spaces* to make its mark on the new building, as exhibit science maps, a macroscope kiosk, and the Illuminated Diagram quickly took up residence in spaces throughout the building!

Although our physical location has changed, our deep commitment to the exhibit remains the same. Throughout the year, we are hard at work managing the submission, review, and selection process for all new macroscopes. We also coordinate the display of exhibit pieces at venues worldwide, organize workshops and events, publicize exhibit activities, obtain translations of exhibit text, and facilitate the archiving of exhibit maps in major libraries—our most treasured repositories of knowledge. Finally, we collaborate with experts at Indiana University and around the globe to ensure that our ambitious goals for the exhibit are evident in all its physical and digital forms.

No doubt, this work keeps us busy. It also brings us a large measure of joy. One of the great pleasures of curating an exhibit such as this is to witness the ways in which audiences respond to the maps and macroscopes themselves, and how extraordinary collaborations and deep friendships are created in the process. It is in this wonderfully personal moment of meaningful interaction that we see our greatest hopes for the exhibit made manifest before our eyes.

These opportunities for insight would not be possible without extensive support by the many friends of the exhibit and the *Places & Spaces* staff members that keep the exhibit moving forward. Esmé Middaugh, a master's student in data science, expertly manages the exhibit's travel around the globe and employs her considerable knowledge of visualization in working with macroscope makers and advisory board members. Todd Theriault ensures elegant communication across the many diverse communities that embrace the exhibit. Thanks, too, go out to our exhibit ambassadors for their work in promoting, communicating, and transporting *Places & Spaces* in their own communities. It is our sincerest hope that your contributions are abundantly evident and reciprocated by everyone who sees this exhibit.

Curators Katy Börner (left) and Lisel Record (right).

Introduction to the Exhibit

For centuries, human beings relied upon maps and navigation tools to guide them safely through unfamiliar geographical territories. Armed with chart, scope, and compass, individuals were emboldened to venture to places previously visited only in the imagination. Today, the Global Positioning System and Google Maps have become so ubiquitous that modern travelers seldom experience the truly helpless feeling of being physically lost.

The same, however, cannot be said about current travelers of the *information* landscape. Too often, we find ourselves lost in a wilderness of complex data. The moment we get oriented, new data comes in, causing our surroundings to change and expand. What's needed are new navigational tools—modern variations of our ancestors' charts and scopes—to guide us safely, efficiently, and meaningfully through these rich territories of data, information, knowledge, and wisdom.

Did You Know?

Places & Spaces made its debut during the 101st Annual Meeting of the Association of American Geographers on April 5th, 2005 in Denver, CO.

What Is a Science Map?

A science map visualizes research activity and results to support science communication, management, and planning.
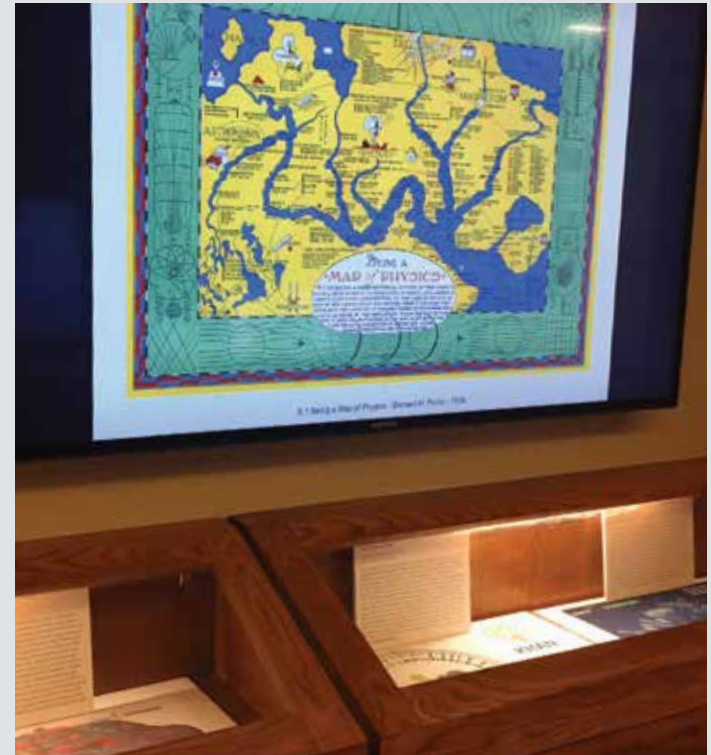
Bernard Porter's *Map of Physics* is a classic of science mapping.

What Is a Macroscope?

Macroscopes are software tools that support data-driven decision making by revealing patterns and trends in large amounts of information.

Macroscopes invite visitors to get "hands-on" with big ideas in science.

For its first ten years, *Places & Spaces* traced the evolution of science maps, featuring key works of knowledge domain mapping, location-based cartographies, and science-inspired art. Since 2015, the exhibit has focused on macroscopes, innovative software tools that allow users to explore vast datasets and locate hidden patterns of significance.

The process of selecting the exhibit's pieces begins each year with a call for macroscopes. Once the submissions have been gathered, our exhibit advisors and curators select the four most innovative and scientifically rigorous works for entry into *Places & Spaces*. Next, our designers and programmers join forces with the macroscope makers to bring four disparate macroscope tools into visual and operational coherence while ensuring they are understandable by a general audience. Finally, the finished macroscopes join previous years' selections in a one-of-a-kind exhibition that travels to libraries, museums, academies of science, universities, and other venues around the world.

Explore Science Maps in Libraries

You can find all 100 *Places & Spaces* science maps in the archives of the American University of Beirut, US Library of Congress, University of Michigan, and Indiana University.

2018 Macroscopes

Climate change, chemical addiction, food demand, and violence are among the most intimate threats to human well-being, and they are often most difficult to approach. While we may be able to implement healthful changes on an individual or even community level, our efforts on a larger scale are often inefficient due to the sheer scope and pervasive reach of these critical social problems.

As the *Places & Spaces: Mapping Science* exhibit has demonstrated, the power of macroscopes consists in finding meaningful patterns in the oftentimes chaotic jumble of massive datasets. In the exhibit's 14th iteration, "Macroscopes for Ensuring Our Well-Being," the focus is on making sense of millions of individual decisions—decisions regarding how we treat our bodies, our neighbors, and our environment. By revealing key trends and patterns hidden in the data, these macroscopes allow policymakers, community groups, and individuals to make strategic decisions benefiting human health and wellness.

As in past iterations, these macroscopes were selected by our expert advisory board and represent the very best that interactive data visualization has to offer. Combining innovative analysis methods and groundbreaking visualization techniques, this year's selections have the power to equip the mind, inspire the spirit, and move the heart.


Curator Lisel Record talks macroscopes at Indiana University's Mini University.
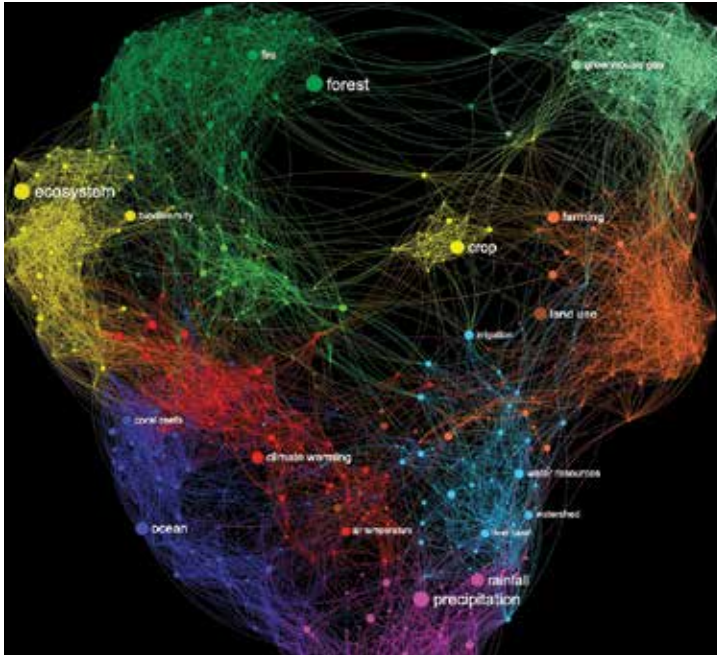
Climate Tweetoscope

Developed by David Chavalarias and Maziyar Panahi, *Climate Tweetoscope* analyzes 30,000 science publications and 47 million tweets to compare the language of scientists and laypeople when discussing climate change. The macroscope reveals points of overlap and divergence, allowing the two groups to develop a common language to describe and share strategies to confront this global crisis.
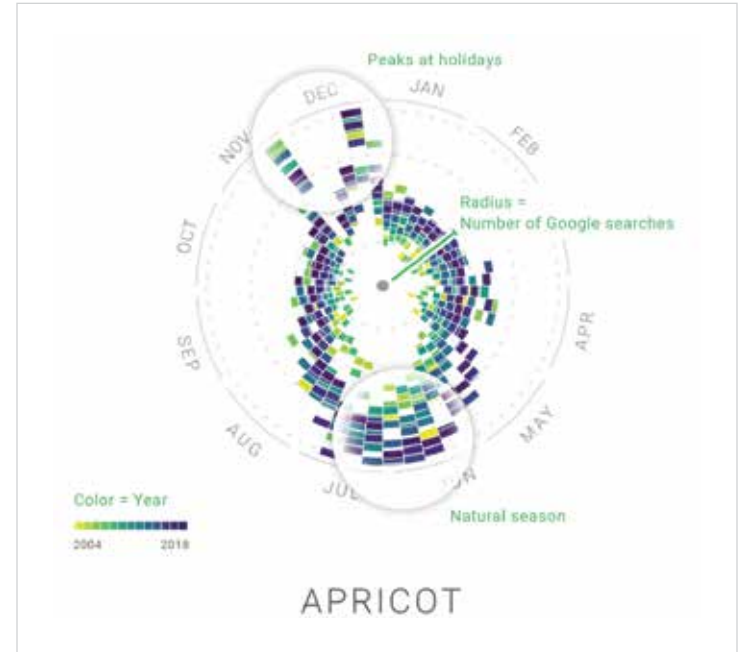
Rhythm of Food

This macroscope by Moritz Stefaner and Yuri Vishnevsky uses a new form of data visualization—a year clock—to show the rise and fall of ingredients, drinks, diets, and regional cuisine through seasons and years. Composed of over 130,000 data points pulled from Google Trends, the *Rhythm of Food* reveals both seasonal patterns and the changing popularity of diet trends and food crazes.
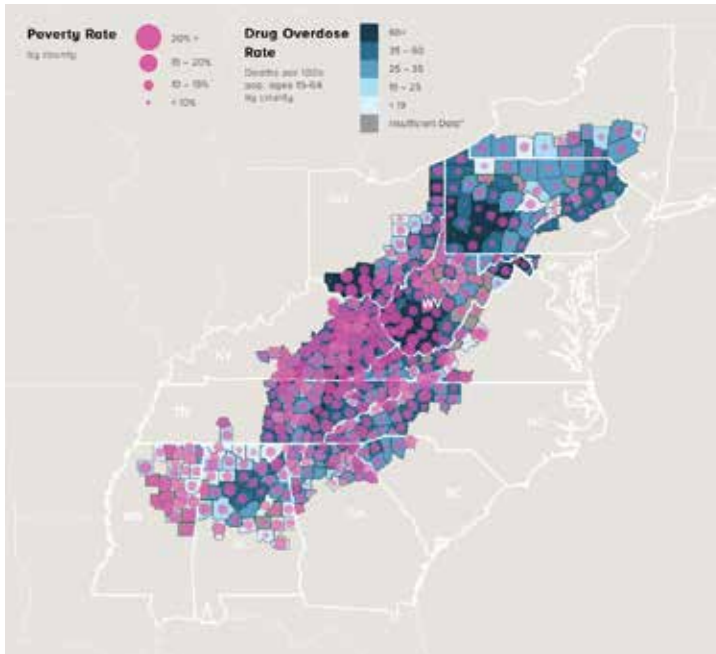
Appalachian Overdose Mapping Tool

Developed by Ned English, Megan Heffernan, Peter Herman, and Michael Meit of the non-partisan research organization NORC, the *Appalachian Overdose Mapping Tool* supports community planning and strategies to confront the opioid epidemic. This interactive visualization allows users to see how the effects of poverty, unemployment, education level, and disability contribute to the scope and severity of the crisis on 420 Appalachian counties.

Violence Info

A project of the World Health Organization (WHO), *Violence Info* draws on over 3,000 scientific studies, health estimates, global status reports, and other crucial documents to examine interpersonal violence at a global scale. By becoming better informed about the data behind tragedies like child maltreatment, intimate partner violence, and elder abuse, the hope is that users can both predict and prevent violence in their own communities.

Exhibit Advisors

The Indiana University exhibit team benefits greatly from the expert input it receives from this international advisory board. Advisory board members review exhibition submissions and provide their expertise and guidance to the exhibit on many levels.

Exhibit advisor Francis Harvey transporting exhibit posters to display.

Gary Berg-Cross is a cognitive psychologist (PhD, SUNY–Stony Brook) who has taught at a number of institutions over his career (SUNY, Widener, University of Delaware, George Washington, George Mason University, and others). For eight years, he served as the Spatial Ontology Community of Practice (SOCoP) Executive Secretariat helping to run workshops and vocabulary development efforts to advance the field. Currently, Berg-Cross serves as a consulting knowledge engineer on earth science projects and is co-organizer of the annual Ontology Summit hosted at NSF and NIST. [Potomac, MD, USA]

Donna J. Cox is the first Michael Aiken Chair, director of the Advanced Visualization Laboratory (AVL) at the National Center for Supercomputing Applications, and director of the Illinois eDream Institute, all at the University of Illinois at Urbana-Champaign. She is a recognized pioneer in Renaissance Teams and supercomputer visualizations for public outreach, and in 2006 she was selected by the Chicago Museum of Science as one of 40 modern-day Leonardo da Vincis. [Urbana-Champaign, IL, USA]

Bonnie DeVarco writes and lectures on design science, virtual worlds, next-generation geographic information systems, information visualization, and the culture of cyberspace. Previously, DeVarco was a Distinguished Visiting Scholar with the Media X Research Network at Stanford University (2009-2012) and served as chief archivist for the Buckminster Fuller Archives. Currently, DeVarco is completing a book on Buckminster Fuller and is coauthor with Eileen Clegg of *Shape of Thought* on the history and evolution of visual language. [Palo Alto, CA, USA]

Francis Harvey is head of the Department of Cartography and Visual Communication at the Leibniz Institute for Regional Geography and professor of Visual Communication in Geography at the University of Leipzig, Germany. His research and teaching activities center around geographic information systems (GIS), particularly their technologies, applications, ethical dimensions, and societal implications. Harvey's *Primer of GIS: Fundamental Geographic and Cartographic Concepts* (Guilford, 2015), is now in its second edition. [Leipzig, Germany]

Peter A. Hook is an assistant professor of library and information science at Wayne State University in Detroit, MI. He received his doctorate from the School of Informatics and Computing at Indiana University where his primary research focus was information visualization, particularly the visualization of knowledge organization systems, concept mapping, and the spatial navigation of bibliographic data in which the underlying structural organization of the domain is conveyed to the user. [Detroit, MI, USA]

Lev Manovich is professor at the City University of New York (CUNY) Graduate Center and author of several books on digital culture, including the recent *Software Takes Command* (Bloomsbury Academic, 2013). In 2007, Manovich founded the Software Studies Initiative in order to develop a new paradigm of Cultural Analytics through data analysis and interactive visualization of patterns and trends in media and visual cultures. [New York, NY, USA]

André Skupin, professor of geography at San Diego State University, is interested in the application of geographic metaphors, cartographic principles, and computational methods to the visualization of non-geographic information. His research is interdisciplinary, aimed at increased cross-fertilization between geography, information science, and computer science. Recent work includes novel methods for visualizing human movement and demographic change as trajectories in n-dimensional attribute space. [San Diego, CA, USA]

Moritz Stefaner is a freelance designer on the crossroads of data visualization, information aesthetics, and user interface design. With a background in cognitive science and interface design, Stefaner's work beautifully balances analytical and aesthetic aspects in mapping abstract and complex phenomena. In 2010, he was nominated for the Design Award of the Federal Republic of Germany, and his work has been exhibited at SIGGRAPH and Ars Electronica. Portfolio at moritz.stefaner.eu. [Lilienthal, Germany]

Olga Subirós is an architect, exhibition designer, and founder of Olga Subirós Studios. Recently, she co-curated (with José Luis de Vicente) *Big Bang Data*, a major exhibition of data-driven artworks and objects that provide crucial insight into the world of big data. Since 2014, the exhibit has toured worldwide, appearing at the Centre de Cultura Contemporània de Barcelona (CCCB), Fundación Telefónica in Madrid, Somerset House London, ArtScience Museum Singapore, Centro de Cultura Digital in Mexico, and the DOX Centre for Contemporary Art in Prague. [Barcelona, Spain]

Stephen Uzzo is vice president of science and technology for the New York Hall of Science where he works on exhibit and program development projects related to STEM learning, scientific visualization, sustainability, and network science. Uzzo also serves on the faculty of the New York Institute of Technology Graduate School of Education, where he teaches STEM teaching and learning. [Queens, NY, USA]

Benjamin Wiederkehr is founding partner and managing director of the Zürich-based design and data visualization studio, Interactive Things. He is also part of the Open Government Data task force in Switzerland and helps to facilitate open access to government data for everyone. On **Datavisualization.ch**, Wiederkehr provides insight into his research and working process and documents topical use cases in the field of data visualization. [Zürich, Switzerland]

Events & Venues

Destination: Luddy Hall

At the beginning of 2018, the CNS Center moved from its longtime home in the Wells Library to the spacious fourth floor of the newly constructed Luddy Hall. The 124,000 square-foot building brings together Indiana University's five departments of information and library science, informatics, statistics, computer science, and intelligent systems engineering under one roof as the School of Informatics, Computing, and Engineering (SICE). The building houses

Aerial view of Indiana University's new Luddy Hall.

Exhibit maps adorn the passageways of Luddy Hall

the visualization lab, a maker space and three other intelligent systems labs, 10 conference and focus rooms, 264 student workspaces, and the Shoemaker Innovation Center. During its dedication on April 13, Indiana University president Michael McRobbie predicted that Luddy Hall would "inspire creativity, discovery, and innovative achievement." As is evident from the surrounding pictures, *Places & Spaces* has already made its mark with science maps, illuminated diagrams, and macroscope kiosks beautifully complementing the walls and pathways of this remarkable building.

Andreas Bueckle, Katy Börner, and Mike Hu beneath Amatria.

Close-up of Amatria at the unveiling ceremony during LuddyFest.

Amatria

If you visit us on the fourth floor of Luddy Hall (and we hope you do!), you will be amazed at what you find watching over our new home. Amatria, a work of sentient architecture designed by Canadian architect Philip Beesley specifically for the building, is a seemingly living presence made up of canopies of 3D-printed fronds, hollow tubing, LED lights, motion sensors, and fluid-filled bulbs. The term "sentient architecture" refers to Amatria's seamless conjoining of art, architecture, and intelligent systems technology. As people move through the building, Amatria responds by sensing, processing, and physically reacting to the activity data she's receiving. The catalyst for the work was a meeting between Beesley and exhibit curator Katy Börner at a Keck Futures Conference organized by the National Academies a few years back. Börner was captivated by the work created by Beesley and his Living Architecture Systems Group and pitched the work to Indiana University's School of Informatics, Computing, and Engineering as an effective means to introduce intelligent systems thinking and design to Indiana University, Bloomington, and beyond. Amatria at Luddy Hall has become a place for discussing the impact of AI on our lives, running Yoga sessions, and taking graduation and wedding photos. Even more important, she serves as a testbed for IoT and visualization research. For example, an interface designed by Andreas Bueckle helps visitors understand the location and type of Amatria's diverse sensors and actuators; it comes with a brief introduction to the sculpture and instructions on how to modify camera angles and the data on display.

Selected Venues

This year, *Places & Spaces* enjoyed a three-month residency in the Scholars Commons at Indiana University's Wells Library. The display featured both digital and printed versions of the science maps, a macroscope kiosk, filmed interviews with exhibit contributors, the *Humanexus* film, and the illuminated *WorldProcessor Globes*.

Places & Spaces at the Scholars Commons at Indiana University's Wells Library.

Lisel Record presenting at the Association of Science and Technology Centers conference in Hartford, CT.

We also had the wonderful opportunity to display the poster version of the exhibit at the famed University of Leipzig during the European Summer University in Digital Humanities. As the workshops offered during the two-week session emphasize the "practical application of methods and skills," the exemplary visualizations featured in *Places & Spaces* served as inspiration for the students' own work.

Research

Fashion Technology Symposium

Computing devices are everywhere, including internet-connected refrigerators and coffeemakers. The Internet of Things (IoT), built from networks of everyday objects that send and receive information via the internet, is primed to expand to every corner of our lives. And the *Places & Spaces* exhibit is well positioned to be there when it does. The Fashion Technology Symposium—a tri-school effort including Katy Börner and Lisel Record at SICE, Kylie Peppler at the School of Education, and Kate Rowald at the School of Art Architecture and Design—showcased the way advances in IoT, robotics, smart and soft materials technology, artificial intelligence, mind-reading devices, and visual analytics could be applied to the world of fashion and design. Over the course of the two-day workshop, participants discussed promising fashion technology applications, witnessed tech demos and fashion exhibits, and engaged in fruitful brainstorming sessions with others in the field. Seven female speakers in fashion technology from fields as disparate as robotics, human-computer interaction, art, mechanical engineering, and expressive computation highlighted the rich leadership contributions of women at the intersection of fashion and technology.

Stunning creations from the intersection of IoT and fashion.

Examining costumes worn by Glenn Close as Cruella de Vil in *101 Dalmations* housed in the Sage Fashion Collection at Indiana University's School of Art, Architecture + Design.

HelloResearch!

In October, Katy Börner, Andreas Bueckle, and Mike Hu led a team in HelloResearch, a three-day, research-based workshop for undergraduate women to work on exploratory problems in teams led by researchers from academia and industry. Entitled "Augmented Reality Visualizations of IoT Data," the workshop offered hands-on experience for students to assemble Amatria-related Moth sculptures, construct an informative manual for future developers, and present their research results in a conference setting.

Members of the *Augmented Reality Visualizations of IoT Data* workshop.

Nearly 100 undergraduates from all over the US participated in HelloResearch!

A Focus on Public Health

Along with the 14th iteration's focus on well-being, two other initiatives during 2018 highlighted the ability of data visualization to promote targeted research, intelligent policymaking, and informed decisions about issues affecting public health. This year, the CNS Center was awarded two projects associated with Indiana University's Grand Challenge, "Responding to the Addictions Crisis." Indiana University's Grand Challenge program addresses major, focused, and large-scaled problems facing humanity that can be solved only by teams of dedicated researchers working across disciplines in collaboration with community partners. This initiative seeks to curtail addiction in our home state of Indiana, decrease opioid overdose fatalities, and reduce the number of infants born with Neonatal Abstinence Syndrome. CNS will develop visualizations to track progress and change affected by Grand Challenge teams.

In addition, CNS joined the National Institutes of Healths funded Human BioMolecular Atlas Program (HuBMAP) program that aims to develop an open and global platform to map the 37 trillion healthy cells in the human body (**commonfund.nih.gov/hubmap**). As part of a large-scale collaboration with research facilities across the United States, CNS will develop novel tools for spatial and semantic tagging, searching, filtering, and visualizing anatomical and single-cell data to construct an atlas of tissue maps. As this is an eight-year project, expect to hear more about our contributions in future annual reports.

PNAS Special Issue

In 2018, our work was featured in *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, one of the most influential forums for scientific thought. In December, a special issue on "Modeling and Visualizing Science and Technology Developments" collected papers from the Arthur M. Sackler Colloquium of the same name. Along with an introduction co-written by colloquium co-organizer Katy Börner, CNS authors Börner, Olga Scrivner, Shutian Ma, and Mike Gallant contributed to a paper addressing skill discrepancies between research, education, and jobs.

The Arthur M. Sackler Colloquia, sponsored by the United States National Academy of Sciences, are widely known for addressing timely scientific topics of broad interest that cut across traditional disciplinary boundaries. "Modeling and Visualizing Science and Technology Developments," organized by Katy Börner, exemplified that spirit as it brought together researchers and practitioners from multiple disciplines to present, discuss, and advance computational models and visualizations of science and technology (S&T). All talks from this event are available on the NAS Colloquia YouTube channel (**youtube.com/user/SacklerColloquia**).

Cover of the December 11, 2018, edition of *PNAS*.

Host the Exhibit

Put your institution on the map by hosting *Places & Spaces*. The exhibit consists of 100 framed, high-resolution maps, and 16 interactive macroscopes that travel on a touchscreen kiosk. Ingo Günther's *WorldProcessor Globes*, hands-on science maps for kids, the *Illuminated Diagram*, and the award-winning film *Humanexus* are also included. Give your audience the chance to play with data and make sense of science and technology developments.

The *Places & Spaces* exhibit travels in a variety of formats to fit every space and budget. Explore our all-digital options, purchase individual maps, or purchase a poster version of the exhibit. Our digital display is a high-resolution slide show of 100 exhibit maps, optimized for showing the full breadth of the exhibit on one screen. The majority of our exhibit maps are also available for individual purchase or as an archival set. All maps are 24" x 30" (61 x 76 cm) and can be ordered as inkjet prints, high-quality archival prints, and framed prints. Visit our website to explore the many ways you can bring the exhibit to your space (**scimaps.org/store**).

Contact us at **recorde@indiana.edu** for a quote and to check availability for your exhibition dates.

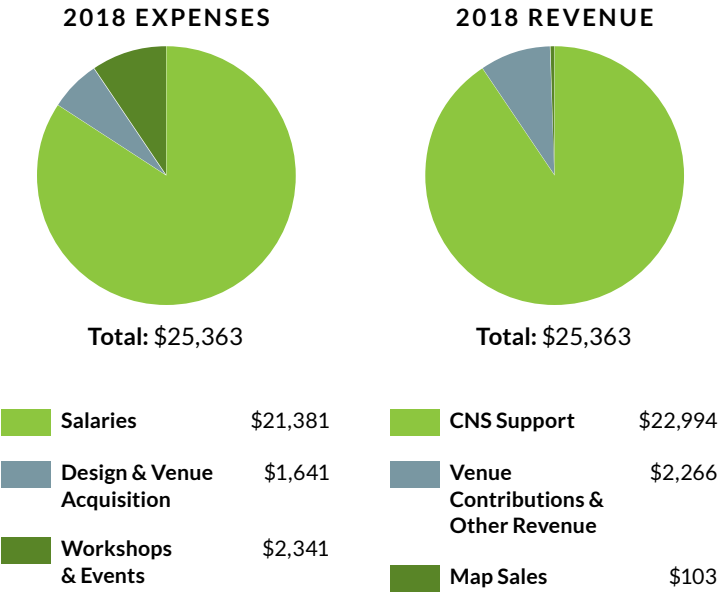Taking part in the Summer University in Digital Humanities at the University of Leipzig.

At the Scholars Commons of Indiana University's Wells Library.

Exhibit in Numbers

Finances

Exhibit finances are managed by the Cyberinfrastructure for Network Science Center at the School of Informatics, Computing, and Engineering at Indiana University. Shown below are exhibit income expenditures for January 1–December 31, 2018.

2018 EXPENSES

Total: $25,363

	Salaries	$21,381
	Design & Venue Acquisition	$1,641
	Workshops & Events	$2,341

2018 REVENUE

Total: $25,363

	CNS Support	$22,994
	Venue Contributions & Other Revenue	$2,266
	Map Sales	$103

100
MAPS
in large format, full color, and high resolution.

215
MAPMAKERS
from fields as disparate as art, urban planning, engineering, and the history of science.

43
MACROSCOPE MAKERS
including one whose job title is "Truth and Beauty Operator."

16
MACROSCOPES
for touching all kinds of data.

385
DISPLAY VENUES
from the Cannes Film Festival to the World Economic Forum.

221
PRESS ITEMS
including articles in *Nature*, *Science*, *USA Today*, and *Wired*.

Resources

Books and Essays

Börner, Katy. 2010. *Atlas of Science: Visualizing What We Know*. Cambridge, MA: The MIT Press. (**scimaps.org/atlas1**)

Börner, Katy. 2015. *Atlas of Knowledge: Anyone Can Map*. Cambridge, MA: The MIT Press. (**scimaps.org/atlas2**)

Börner, Katy, and David E. Polley. 2014. *Visual Insights: A Practical Guide to Making Sense of Data*. Cambridge, MA: The MIT Press.

Börner, Katy, William B. Rouse, Paul Trunfio, and H. Eugene Stanley, eds. 2018. "Arthur M. Sackler Colloquium on Modeling and Visualizing Science and Technology Developments." Special issue, *PNAS* 115 (50): 12573-12661.

Börner, Katy, Adam Maltese, Russell Nelson Balliet, and Joe Heimlich. 2015. "Investigating Aspects of Data Visualization Literacy Using 20 Information Visualizations and 273 Science Museum Visitors." *Information Visualization* 15 (3): 198-213.

Boyack, Kevin W., and Katy Börner, eds. 2014. "Mapping Science." Special issue, *Bulletin of the Association for Information Science and Technology* 41 (2).

Scharnhorst, Andrea, Katy Börner, and Peter van den Besselaar, eds. 2012. *Models of Science Dynamics: Encounters Between Complexity Theory and Information Sciences*. Berlin: Springer-Verlag.

Shiffrin, Richard M., and Katy Börner, eds. 2004. "Mapping Knowledge Domains." Special issue, *PNAS* 101 (Suppl. 1).

Tools

Science of Science (Sci2) Tool (**sci2.cns.iu.edu**) is a desktop application that was specifically designed for the study of science. It supports the temporal, geospatial, topical, and network analysis and visualization of data sets at the micro (individual), meso (local), and macro (global) levels.

Courses

The IVMOOC (**ivmooc.cns.iu.edu**) course provides an overview about the state of the art in information visualization. It teaches the process of producing effective visualizations that take the needs of users into account.

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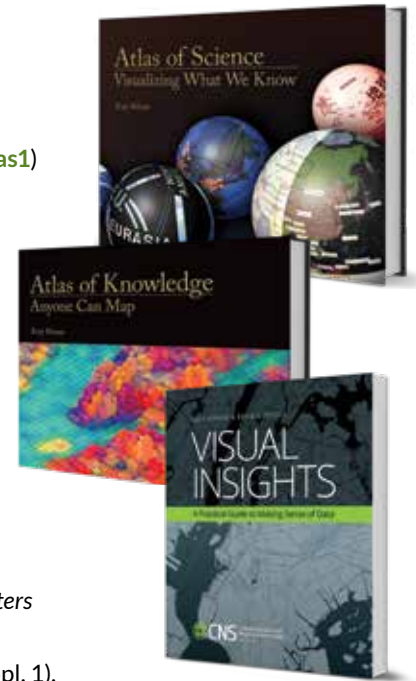
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