Image and Meaning Mini-Workshop

SIGMA XI CENTER
RTP, NC
06.02.06

A Compendium of Submissions

The IM2.*x* series of workshops is designed to further the collaborative exploration to discover new visual expressions in science and technology. The series is a joint project of MIT's Envisioning Science Project, Harvard University's Initiative in Innovative Computing and Sigma Xi, the Scientific Research Society.

Supported by: MIT's School of Science and Office of Research, the National Science Foundation and Harvard University's Initiative in Innovative Computing.

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Graduate student, former intelligence officer, and comics artist; physics undergrad, info design MS degree; interests in tangible UIs, HCI, interactive narrative, and educational technology.

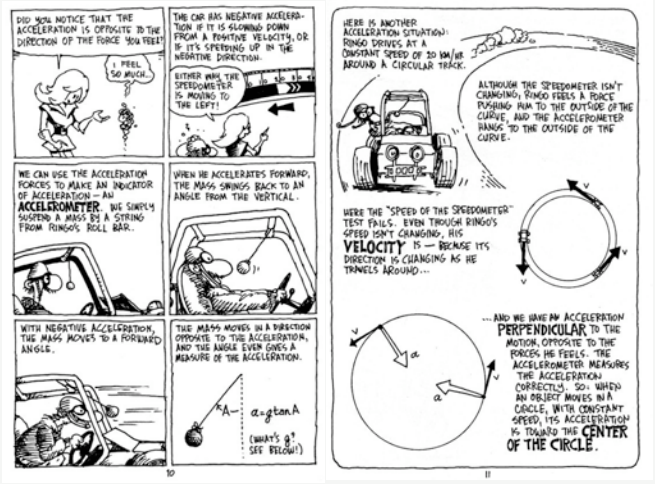
Scientific visualizations often tell stories…as stories are far more memorable to most people than lists of equations or models without context[3], and some researchers believe stories the very form in which humans store their memories[4]. But stories by their very nature usually involve some bit of shortening or summarization, if not some small bits of fiction—narrative generally leaves the "boring parts" out, in order to convey the larger message.

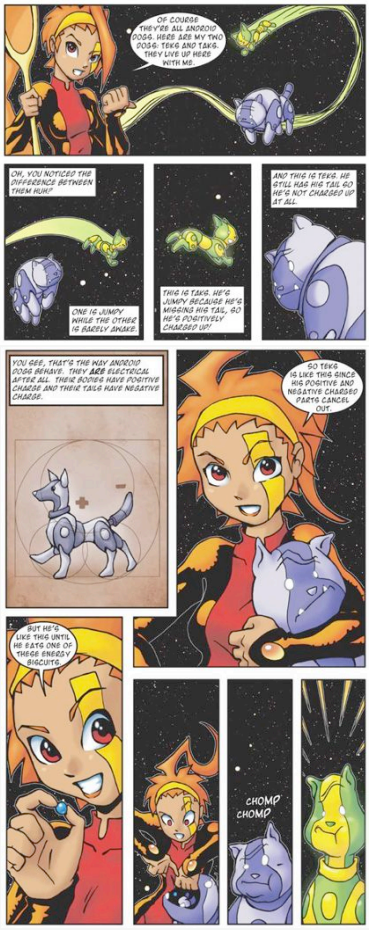
When does the story hinder the understanding of the model being explained, and when does it help it?

Are there heuristics that can be made that can help scientists become better storytellers to share their passion for their work with non-experts?

So that they may make better mental models of their own, in what ways should scientific illustrations encourage the audience to ask questions?

Can modeling the mental models of the target audience assist the visualization in being more effective, and how can the audience be best modeled?





Gonick & Huffman[1] explain acceleration using fictional characters as guides and real-life analogies.

I argue that this is more effective and less confusing than the approach used by Urquhart, et al.[2], in which the fictional characters *are* the metaphors for the equipment and the concept itself.

The conceit that the science is not exciting enough on its own that it has to be enlivened (satellites have to be turned into android girls, ions into space robot dogs), could be harmful and may create metaphors that are too shallow to withstand scrutiny as the mental model develops.

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[1] Gonick, L., and Huffman, A. (1991). *The Cartoon Guide To Physics.* New York, NY: HarperPerennial.

[2] Urquhart, M., Hairston, M., Lervold, E., et al. (2006). *CINDI in Space.* Retrieved October 12, 2005, from http://cindispace.utdallas.edu/education/cindi_comic.html

[3] Kay, A. (1995). *Powerful Ideas Need Love Too! Remarks to a Joint Hearing of the Science Committee and the Economic and Educational and Opportunities Committee*. Retrieved October 13, 2005, from http://lcs.www.media.mit.edu/groups/el/events/love-too.html

[4] Schank, R. (1990). *Tell Me A Story.* New York, NY: Charles Scribner.

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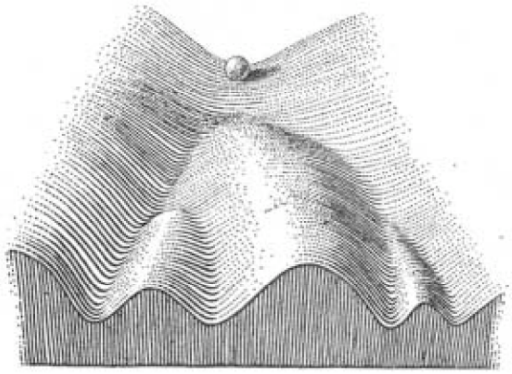
Fields of Expertise: neuroscience, genetics, evolution, protein folding

General Questions: I'd like to talk about when animations are and are not appropriate for use in lectures and website materials. I would also like to talk about copyright issues to keep in mind when putting images on a lab website.

Specific Questions: How do I handle adaptations of published diagrams and illustrations that I might want to use for teaching purposes? When can I post an adaptation on a website or use it in a talk? How do I set up and organize my own image files in the lab so that I can efficiently fulfill requests for images from journalists and other interested parties? What are the considerations for images used on the covers of scientific journals?

Image 1 (example):



"The Epigenetic Landscape" taken from the work of C.H. Waddington (1957). The image represents the different paths a cell or an organism (the ball) can take during development to arrive at a final adult phenotype. The downhill slope shows the flow of time from birth to adulthood, the hills and valleys represent the relative ease of following a given developmental pathway. It is noteworthy that this image was developed before our modern understanding of genetics, yet it foreshadows the roles genes and the environment play in affecting developmental signaling processes.

Image 2 (unsolved problem):

I would like to find ways to make complex problems in protein folding and evolution more understandable to a broad audience through the use of concrete or familiar images.

For example, the heat shock protein, Hsp90, chaperones signaling molecules in order to allow different genetic alleles of those molecules to express similar, robust phenotypes under normal condition. High levels of Hsp90 in an organism will therefore hide a cache of underlying genetic variation. These high levels of Hsp90 could be represented by the water at high tide in the left-hand image, which hides the ocean floor and the bottoms of the rocks. When Hsp90 levels are reduced, as the water is in the right-hand image, a new landscape of genetic variation is revealed. Most of the genetic variation will yield uninteresting or deleterious phenotypes, represented by the blank sandy bottom that is revealed. But a few may be interesting, or enable new functions for organisms, represented by the people walking on the newly revealed ground.

IM2.1 Submission

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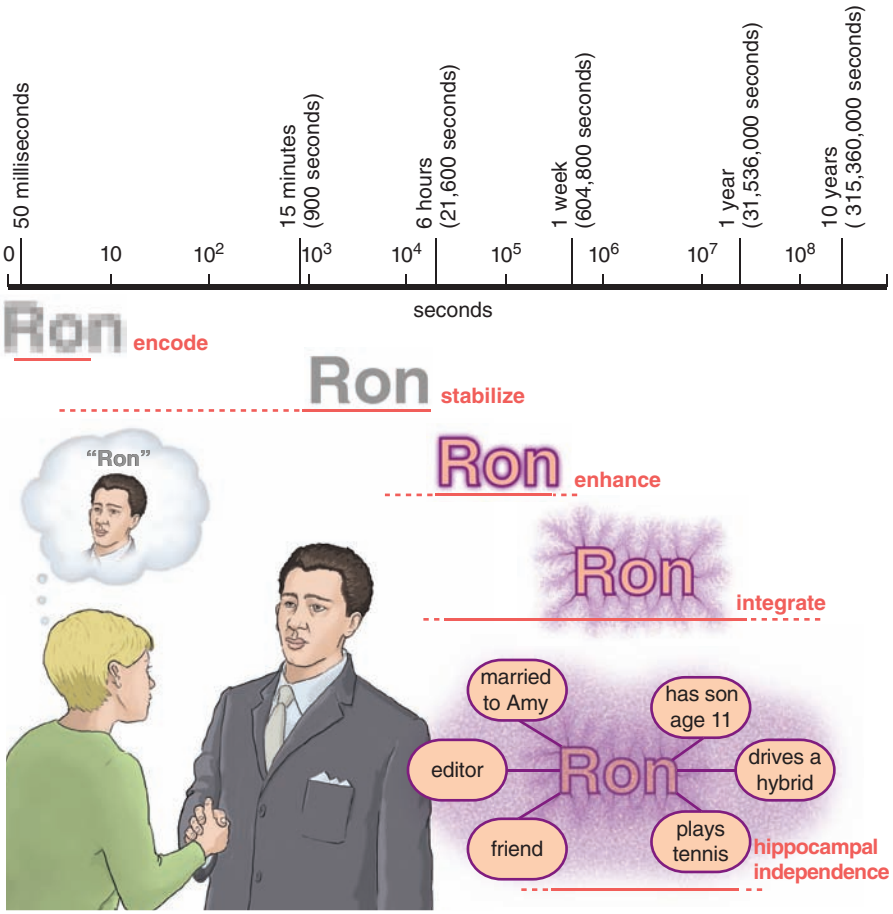

General Questions

Which ideas should be expressed in pictures and which in words? How can the use of good visual design principles bring clarity to illustrating a scientific concept?

Specific Question

How can abstraction and metaphor be effectively combined with data to illustrate complex biological processes in time?

Problematic Image

The goal here was to illustrate memory formation and consolidation shown in successive stages. The steps occur on a continuum. The author provided a simple graph in logarithmic time scale, with five steps: encoding, stabilization, enhancement, integration and hippocampal independence. The solid red lines represent periods of known processing. The dashed red lines indicate hypothesized periods of processing.

To illustrate the time course of memory processes the editor's idea was to show two people meeting and how the memory of a person's name is processed and made part of a permanent record. The different type treatments of "Ron" are meant to serve as metaphors for what is happening in each stage.

Some problems with this image:

1. Is this two illustrations squeezed into one?

2. The reader doesn't get the relationship between the red lines and the time line. Visually the illustrated stages curve around the two figures and pull the reader and the red lines away from the timeline.

4. Are the fanciful type treatments of "Ron" really doing the job of describing what is going on in each memory stage, especially in the last segment "hippocampal independence" where "Ron" sprouts bubbles of association. Do these associations suddenly form in the last stage? What is happening in the "integrate" stage? Maybe accompanying images of a brain for each step showing the area(s) of activity would help describe how the memory is being processed in each of the five stages. Maybe the illustrated "Rons" confuse the reader rather than inform, and words should explain the five stages.

5. The text in the article states that enhancement of memory occurs primarily during sleep. How could this information have been incorporated into the image?

EXPRESSIVITY: ON AN OPTICAL TRANSFORMATION FOR ENVISIONING SCIENCE (2006)

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In this technologically demanding era it is difficult to clarify our intuition about numbers and numerals. By moving off the paper we can find optical display techniques to bridge science (visually structured content) and visualization (adaptive groupings).

What are the visual barriers in graphic arts to doing scientific visualization?

Paper!

Highlighting, transparency, stacking, and porous-solid neighborhoods bring with them an expressive multifaceted boundary system.

How to *cut* and where to *mark* difference in patterns:

Multidimensional
Multiresolution
Particle activity
Genomic complexity
Proteomic expressions
Anisotropic avalanches

Figure 1. Transparency and highlighting mark: quality/quantity/variations in patterns

How can optical behaviors improve the expressiveness of a visualization?

C*³*!

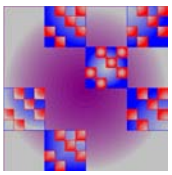
Configurability

Capture

Comprehension

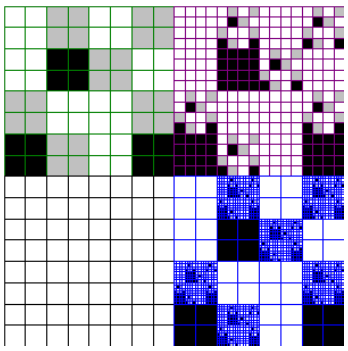
An active ruler-symbol keeps pace with heavy sheets of high-throughput by: 1. cross-referencing thesauri of features (density, unexpected, and hybrid) 2. overlaying multiple dimensions 3. coordination of: intuitive user-defined waveform controls, programmable grids, energy activity in a state/process, and multiresolution visualization expressions of experimental micro-arrays 4. computational modeling (FFT, NMR Spectroscopy)

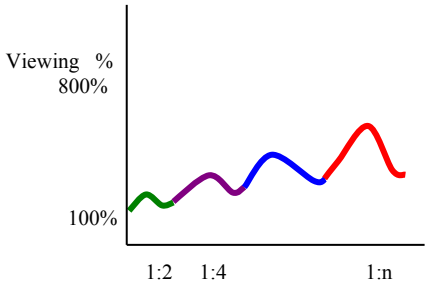
Actual Size



Viewing Size

Display of complex relationships needs uncluttered and expressive presentations.





Ruler-Symbol (Sample grain)

Pattern Detail (Granular dataset)

Deformation Packing Patterns (Porous-Solid-Fractal)

Scale resolution and viewing percentage (User defined)

Figure 2. Activity of packing controls: nested and mutable boundary system

A functional visual treatment (porous, porous-solids, or fractal patterns) is presented as an *activity of nested frames.* These frames index features across the shift of deformation in multi-resolute particle systems (porous or solid). Along side with the screening techniques (spectroscopy and x-ray crystallography) the multiresolution activity of frames results in a conduit for the detailed examination of features. The freedom of porosity packed within several scales of resolution helps to formalize dynamic steps in a process or state.

Physical behaviors (insertion, superimposition, juxtaposition) improve upon the vocabulary for: mapping, designing, and drawing conclusions in an active frame: 1. display in signals 2. filtration and screening systems 3. a dynamic coordinate mapping system. Our first step is to expect that numerals work as well as rulers and boundaries, that is, a numeral can function *reflexively* as well as *expressively*. The intent here is to maintain an expressive numeral system based on physical experience. Otherwise "…if our civilization were to lose its techniques, all our machines and apparatus would become one vast pile of junk."[1]

[1] Barrett, William *The Illusion of Technique*. p.21

Nathaniel Bobbitt has invented a visual writing and character system. Since his *Survey of Visual Paradigms* (LEA MIT-Press) his discoveries include the engineering of an actual fractal space. Founder Nabslab, PI SBIR (DOD,NIH) Proposals, Art-Technologist (CMU, Banff Center, Simon Fraser University). Research area: scientific computing and indigenous visual knowledge systems.

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AREA OF EXPERTISE
Information Visualization, Data Mining & Modeling, Cyberinfrastructure Design, Virtual Reality Interfaces

GENERAL QUESTION
Advanced data analysis and modeling techniques in combination with information visualization can be employed to make sense of large-scale social, business, biological, and other datasets. These new algorithmic techniques are similar to a 'microscope' in that they enable their users to see the structure and dynamics of objects/data that can't be detected with the naked eye. However, different combinations of algorithms as well as (slight) changes in the parameter settings result in drastically different visualizations and interpretations. How can objectivity and readability be achieved?

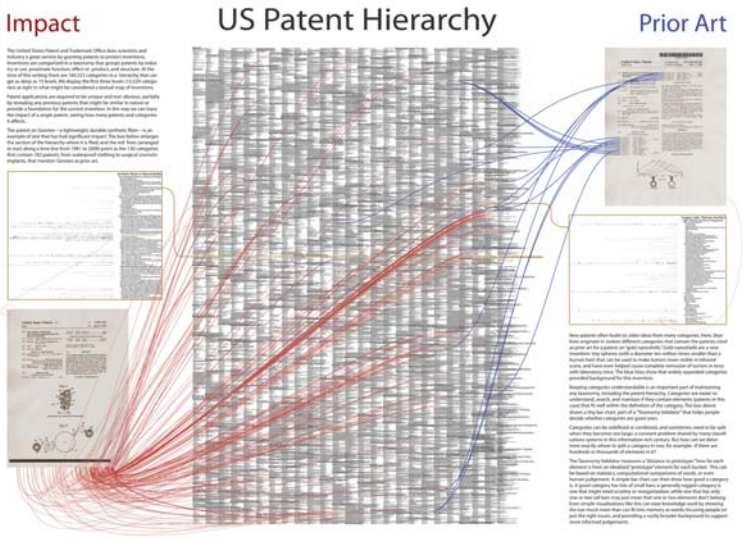
SPECIFIC QUESTION
How can be best depict the structure and evolution of mankind's collective scholarly knowledge? What reference system, what metaphors might work best? How to render the growth, merge, split, decline of scientific fields? How to best communicate the diffusion of ideas over time, geospatial and topic space?

SUCCESSFUL IMAGE & PROBLEMATIC IMAGE

Map of Science for Kids *by Nikki Roberg, Indiana University, 2006.*

Children are able to use it to place major inventions and inventors. They can find a place in science.

See the ***Places & Spaces: Mapping Science*** exhibit at http://vw.indiana.edu/places&spaces for more information on science maps.



Taxonomy Visualization of Patent Data *by Katy Börner, Elisha Hardy, Bruce Herr, Todd Holloway, and W. Bradford Paley, Bloomington Indiana and New York, 2006*

The US patent hierarchy organizes 3.2 million patents into 160,523 categories. Shown are only the first three levels of the hierarchy. Tiny type font and over plotting was used to create a 32 x 40 map. Ten running meters of paper would be needed to plot the complete hierarchy – down to the 15th level in barely readable type font. How to best communicate such an enormous amount of data? How to organize our collective knowledge in a way that we can truly manage and utilize it?

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Field of Expertise: Scientific Visualization and Virtual Reality

General Question(s):

1) How can we imbed uncertainty of information into our representations?
2) Can we show relationships between objects with anything besides a node-link diagram?
3) What is the best way to show the difference between experimental data and a simulation of the same phenomena in 3D data?
4) What is the best way to show time-varying 3D data?

Specific Question: How should computer lighting models be changed to better show the shape of a surface in a static 2D perspective image?

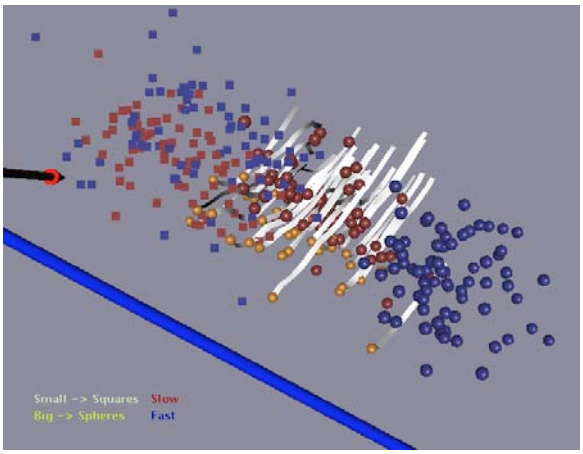

Image #1 (One still image from an animation)

The squares and spheres in the image above represent individual Caterpillars. The gold spheres are the great-great-great grandparents (call them ancestors). The blue and red spheres and squares are the newest generation (call them children). For each generation from the ancestors, the children were selected along two phenotypes: size and development time. Spheres represent large Caterpillars. Squares represent small Caterpillars. Blue shows fast developing Caterpillars. Red shows slowly developing Caterpillars.

Caterpillar development is modeled by a function of 5 variables. The squares and spheres are plotted in 3-space where each axis is one of 3 dependent variables of the model. These three variables are Initial Weight, Critical Weight, and Juvenile Hormone Delay. Theory would predict that the Caterpillars develop along a path of steepest ascent within this 3-space. The white ribbons show the path of steepest ascent for each ancestor.

The visualization clearly shows the ancestors "developing" towards the population of children who are large and develop slowly. This result is consistent with the theory of natural selection that predicts that Caterpillars get larger with a slower development time.

Credit: Tobacco Hornworm data and model by Fred Nijhout, Biology, Duke University

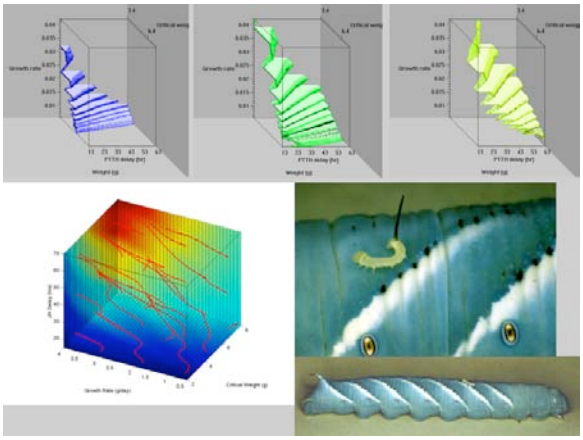

Image #2 –

What is the mechanism (pathway) that allows ancestors to develop into one of the other 3 populations of Children? The solution must be an optimization problem in the space of dependent variables. However, the five variables of the model are non-linear and tightly interconnected. Some of the variables are shown above with different representations. The two images of the Tobacco Hornworm show a caterpillar near birth on the back of a fully-grown caterpillar.

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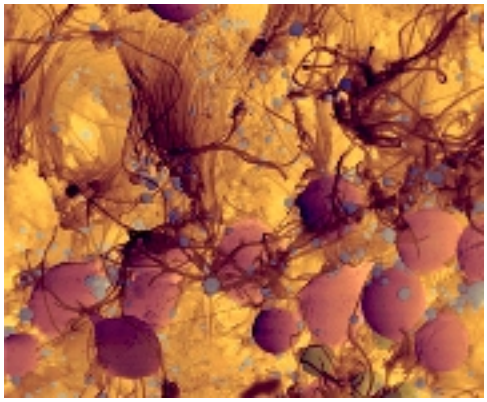
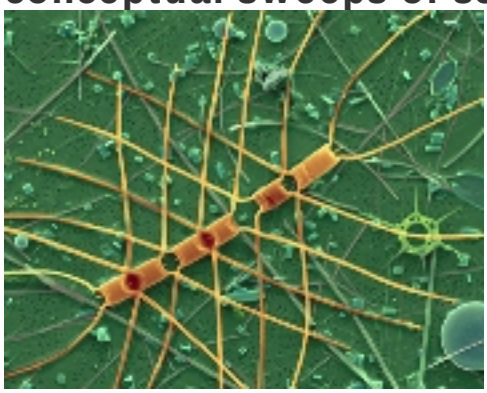
Field of expertise: photomicrographer; educational outreach

I'd like to submit two images from a scanning electron microscope that I think convey information well through cleaning, fixing, massaging, and colorizing of the original black and white electron images.



General concern: discuss proper use of optimized technical imagery from many disciplines as a method to enthrall a science-phobic public with the great conceptual sweeps of science.



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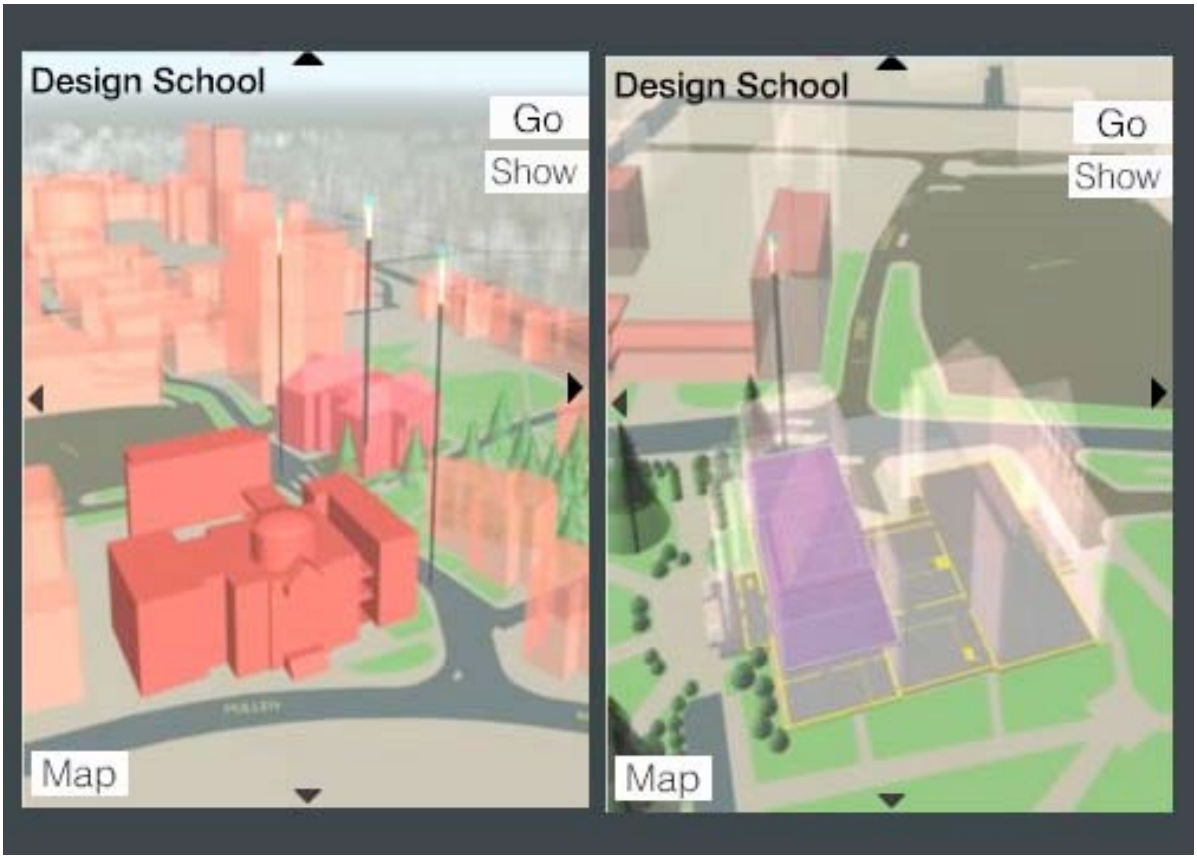
Field of Expertise
Interaction design, 3D animation, visualization

A general question
We are working on a GPS navigation and visualization concept for the PDA. It involves an investigation of dynamically changing detailed information overlaid on a 3D map of a city. The idea is for users/visitors to see a dynamic overview of the area of the city where the user is located, as well as current or historical multimedia information the area may offer the user.

Question:
How might we better express the detailed information of what each building offers without making the GUI cluttered and confusing? How should transparency be use most effectively to display hierarchy in the GUI?



Stephanie Freese • sfreese@amsci.org • *American Scientist* • 3106 E. NC Hwy. 54 • Research Triangle Park, NC 27709

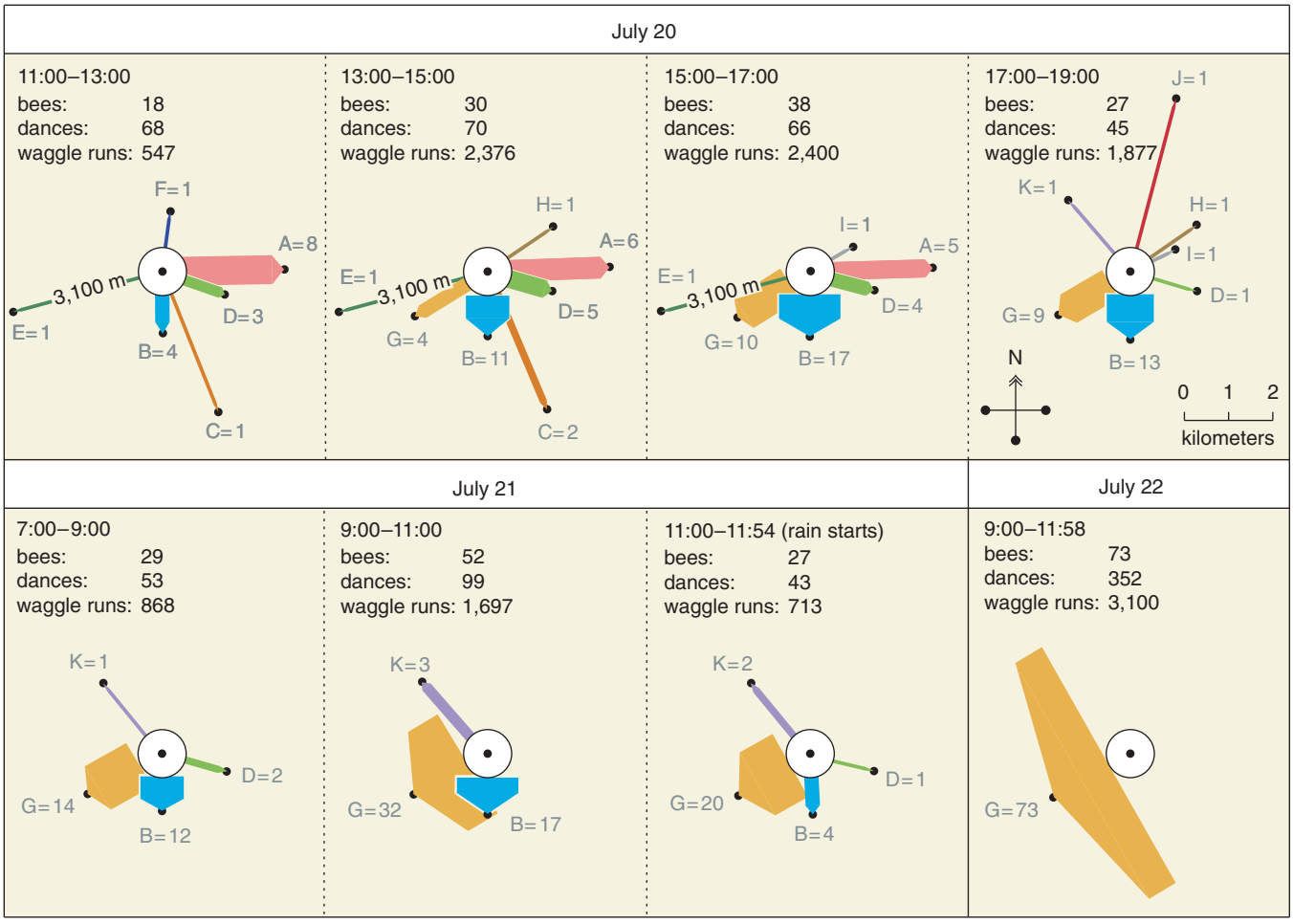
Field of Expertise
Illustration (humans, animals), design

General question
Is basic illustration for print becoming obsolete—will everything one day be multimedia representations of concepts?

Specific question
What are some favored techniques for showing the passage of time?

Problem image
Schematic to summarize a bee swarm's process of reaching a quorum for selecting a new nest site. Original draft came from author. Color was added to increase readability, but questions remain as to whether alternate methods exist for indicating direction, distance, and number of bees.

From caption:
Each panel summarizes a one- to three-hour interval of activity and lists the total number of bees, dances and waggle runs during this interval. The white circle represents the swarm. Candidate nest sites (black dots) are assigned letters in the order in which the bees reported them. Each arrow indicates direction and distance to a site; the thickness of the arrow correlates with how many bees are dancing in support of that site during the interval, as shown by the number next to each site's letter designation. In this case, the swarm considered a total of 11 sites over three days, but none was advertised much more strongly than the others during the first half of the decision-making process. During the second half, however, site G gradually gained support and became the subject of all the dances.



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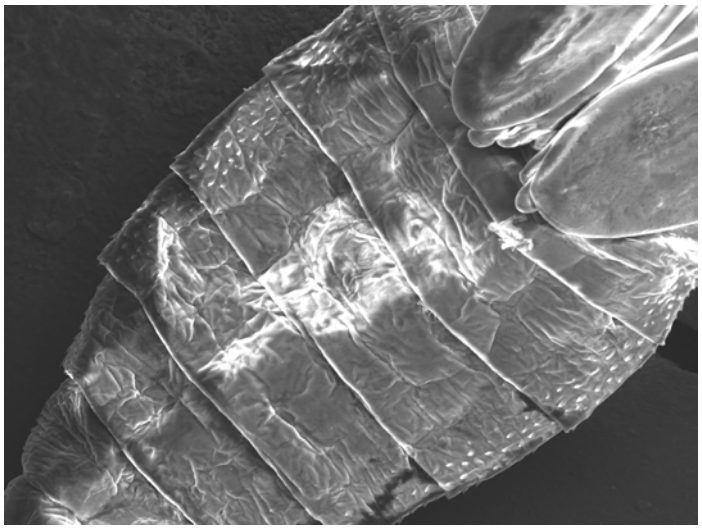
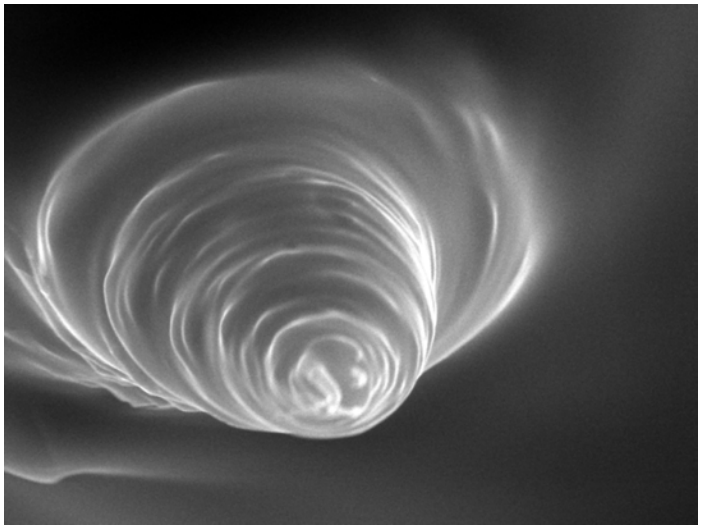
Expertise: Marketing/PR, photomicrography/photography, new media,

Interest: I enjoy working with scientists to find innovative ways to communicate news/information about science-based projects.

Questions:





Does altering a scientific image discredit its accuracy?

What is the best way to get your work published in magazines and to build relationships with editors?

What has been most effective in persuading scientists to work with artists in a collaboration like IM2?

Are there organizations that focus on heavily on science and the art in a collaboration like IM2?

One of my challenges has been working with art galleries. My work doesn't seem to fit into an existing style; please share any ideas and suggestions for exhibiting work in galleries and participating in competitions.

In my frustrations with the art community and exhibitions, I would like to start a gallery in the US for scientific art or sci-art; how could I locate scientists, like Felice Frankel or Eric Heller that also have become artists?

Suggestions for what would be the best way to contact and connect with people in RTP working in science?

My goal is to work in all areas of science, with scientists as a microphotojournalist who communicates research projects to popular audiences without sacrificing any creditability with the scientific community.

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Computer Graphics Specialist
Biomedical Visualization

General Question

What do you see as growing trends in scientific visualization over the next 5-10 years? Technologies, software, platforms, interface, markets, initiatives, collaborations?

Specific Question

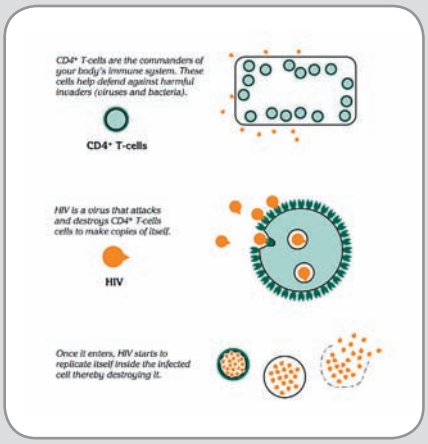
The use and meaning of color between countries and cultures varies greatly. Is there a resource that describes the use of color in different cultures?

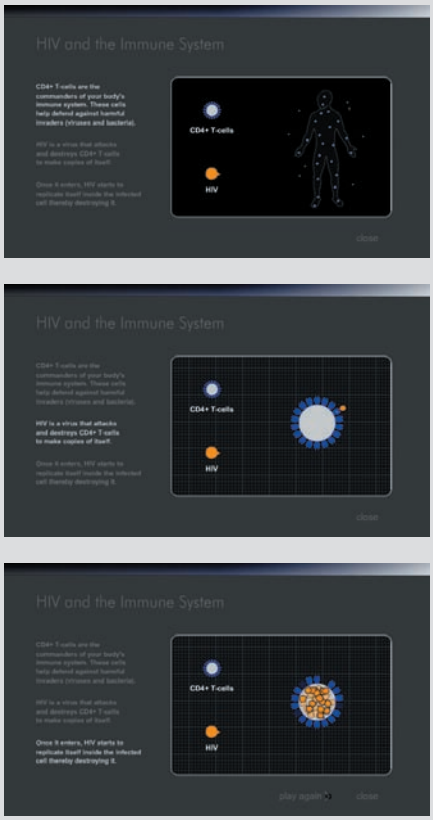
Successful Visual

As the global market continues to develop, and access to technology increases, there will be a greater need for international public education and visualizations in macro research markets, such as AIDS.

Maintaining a consistent look in education and marketing pieces through print-to-digital conversion is important to reach larger audiences. And although each media presents its own challenges, concepts can be successfully communicated with careful information planning and design, with a focus on the relationships between the design elements.

The visuals on the right describe how the HIV virus replicates by invading the host CD4+ T-cells. The original image (left) used in print was converted to flash (right). The simple flash animation is intended to be viewed by an international audience with mid-low education levels, so there was a need to balance accuracy and concept clarity.





Problematic Visual

The image on the right was taken from a report on the quality of streams in the US. The amount of information in this single graphic is exaustive, and is in need of an innovative redesign. There are a total of nine different regions in this report.

Figure 3-2. WSA survey results for the Northern Appalachians ecoregion.

Bars show the percentage of stream length within a condition class for a given indicator. Lines with brackets represent the width of the 95% confidence interval around the percent of stream length. Percents may not add up to 100 because of rounding.

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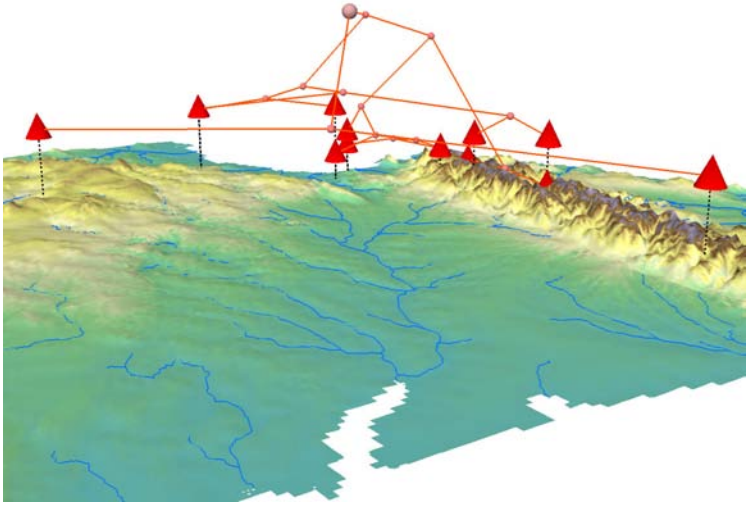
Field of Expertise: I am a geographical information scientist interested in understanding how Earth history has structured the patterns of biodiversity we observe today. Biodiversity includes genetic, biochemical, morphological behavioral and ecological variation within and between species.

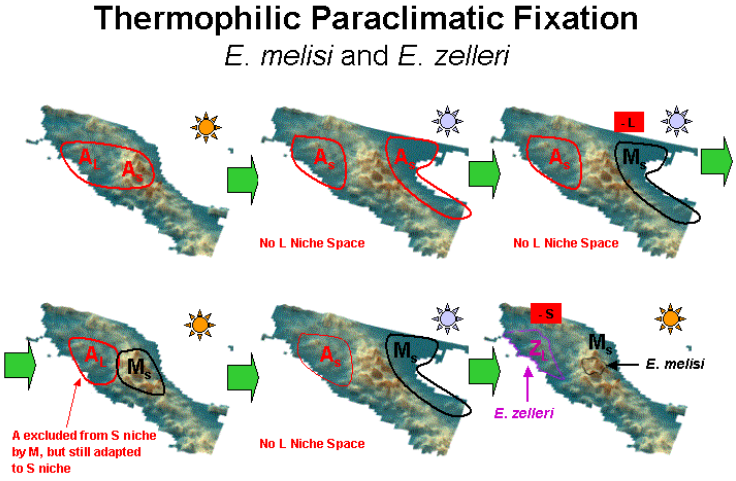
General Question
How to display multiple attributes that change in space-time as a single 2D image?



Successful Image: A phylogenetic tree over a single (modern) 2.5D landscape.

Specific Question
Evolutionary histories are the intersection of attributes that exist in three intersecting multidimensional 'spaces', nD 'organism space', nD 'ecological niche space' and 4D space-time.

How can I visualize linked change in organism variation and niche space occupancy along evolutionary trees and networks that evolved across changing landscapes?



Problematic Image: Hypothesized evolutionary scenario for the diversification of sister taxa across multiple glacial-interglacial cycles. An ancestral species (A) has a large form (A_L) and small form (A_s) occupying warm lowland and cool montane environments respectively. During glacial periods there is no warm climate available so no A_L is observed. Loss of niche space occupancy potential is indicated by red rectangles.

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Harvard University Herbarium; 22 Divinity Avenue; Cambridge, MA 02138

Fields of expertise: *In vitro* selection/RNA evolution, plant light perception, scientific screen-writing.

General Question:

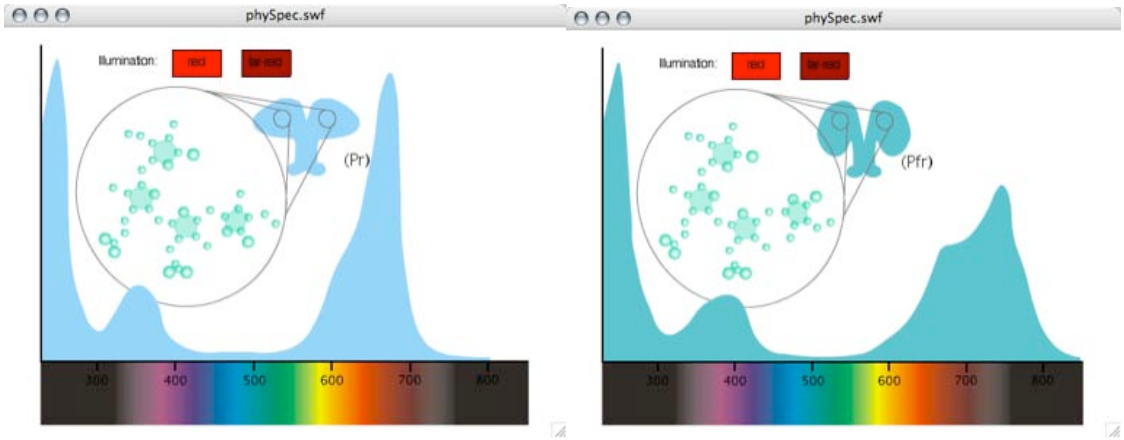
How can I visually represent the establishment of emergent biochemical/biological properties (such as the naissance of macromolecular functionality out of specific chemical combinations and conformations)?

Specific Question:

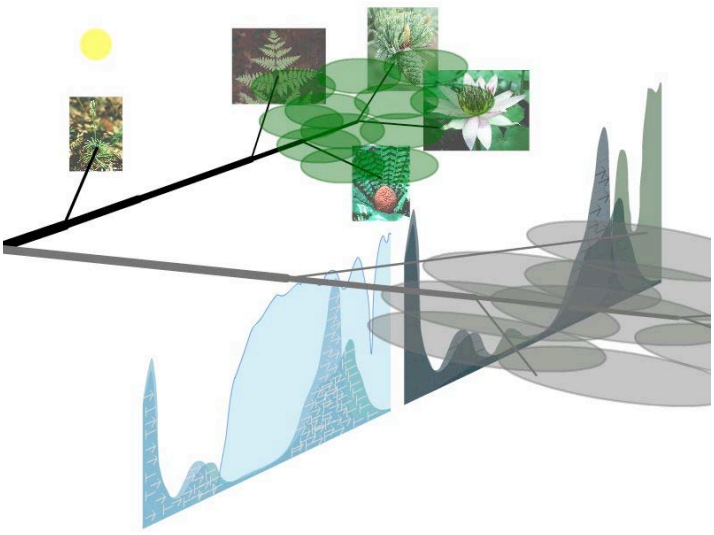
How can I visually correlate phylogenetic information with functional specification, diversification and ecological adaptation?

Images:

1. Animated absorption spectra of phytochrome, a plant red/far-red photoreceptor. This animation (please visit http://www.huh.harvard.edu/research/mathews-lab/phyAbsSpec/index.htm to view) is effective because it clearly shows the relationship between the chemical structure of the phytochrome chromophore and its corresponding absorption spectra. In addition, the image demonstrates the corresponding change in the holoprotein conformation.



2. I am currently working on an image that may well serve as the cover image to accompany my professor's invited review of the evolution of phytochrome photosensors in the Journal of Molecular Ecology. The challenge of this image is in showing the diversification of phytochrome function that correlates to the ecological emergence of a light-filtering leaf canopy. As such, this composite sketch attempts to address such visually complex notions as plant phylogeny (including both extant and extinct species), the qualitative difference between the daylight and canopy-filtered spectra, the corresponding spectra of the respective red and far-red absorbing phytochrome comformations (see image 1), and the divergence of phytochrome function in the plants that have evolved since the emergence of the canopy. I also hold the personal hope to adapt the image to demonstrate the different realms of the phytochrome action: the incident of quanta-induced quantum rearrangement (chromophore isomerization upon the absorption of light), the subsequent macromolecular conformation change of the surrounding holoprotein, the relocalization of phytochrome to the nucleus, the interaction with transcription factors and the proteosome, and the resultant changes in plant morphology. Though the representation of all these mechanistic steps will undoubtedly make for a very busy image, I am motivated to establish an elegant composition capable of conveying the Rube Goldbergesque processing of light energy and the resultant ability of plant to perceive changes in their local light environment.



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IM2.1 Attendance Submission

Background

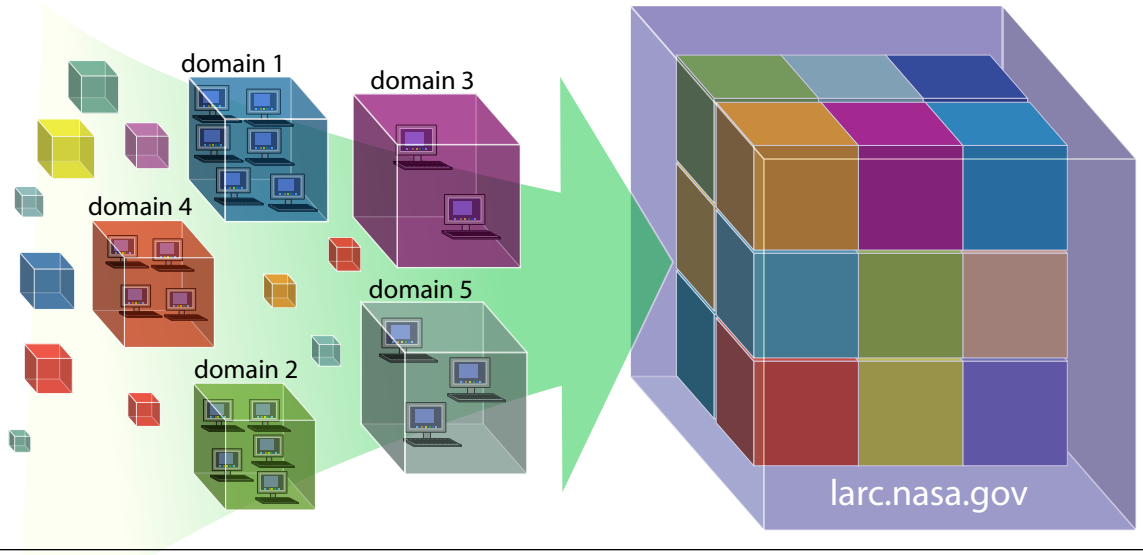
I am a creative and skilled professional artist with 20 years experience in illustration, design and creative media including traditional and digital methods. I also have expertise in conveying technical subjects to a broad, non-technical audience.

Challenges

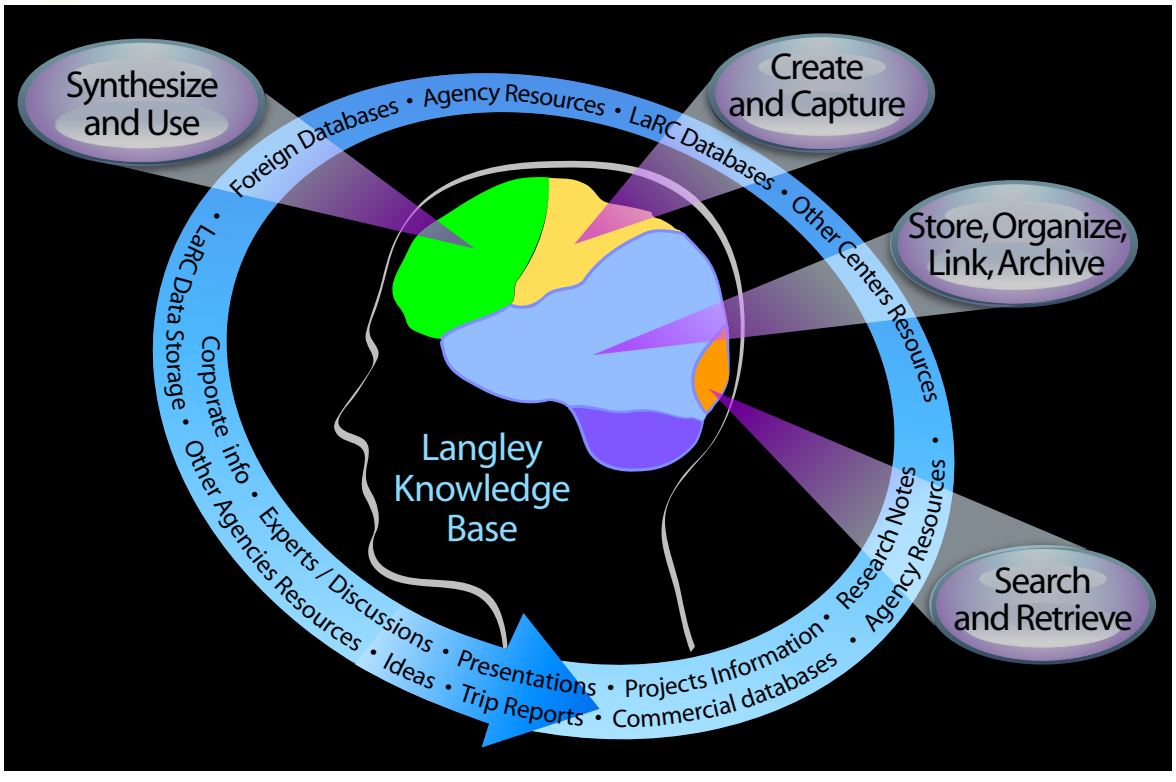
General - Finding new methods and techniques to inform, educate and, in some cases, entertain the perspective audience.

Specific - Accurately portray the passage of time with a static image. I find the generic timeline unsatisfactory in portraying the nuances of time.

1 - A visual explanation of how subdomains integrate within a domain (subnetting)



2 - Illustration attempting to show the concept behind Knowledge Management systems



Eric J. Pyle, Ph.D.
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MSC 6903
Dept. of Geology & Env. Science
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Expertise: Construction and evaluation of instructional visual and text materials in the Earth sciences for grades 6-12 and introductory Geology; Earth science teacher education.

Steven J. Whitmeyer, Ph.D.
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Expertise: Field-oriented structural geology and global tectonics with an emphasis on 3D and 4D and presentation of geologic and tectonic processes.

General Question: How can multidimensional and time-space-material relationships and complex Earth systems relationships be visualized and adapted for interactive interfaces to enhance student learning in middle, secondary, and higher education?

Specific Question and Abstract: The diagram on the right, constructed by Steve Whitmeyer, represents one stage in the accretionary history of the North American continent. As such, it is highly detailed but static with respect to understanding, requiring juxtaposition with diagrams representing different points in geologic time. It represents spatial relationships, with secondary information on rock types and ages. The image on the right by Eric Pyle is also problematic, representing the process relationship of components of climate to the type of physical geology that should be expected as a result of climate. In doing so, it represents the interrelationship between incoming solar radiation and proximity to the ocean for a climate, without specific information about place or time. A central challenge of our work is to combine the time-space and petrologic relationships of continental reconstructions and positions with the complex relationships that define biomes, climates, and environments over vast spans of time. Thus, a specific question for IM2.1 is to determine how to combine these elements into a student-oriented interface for understanding complex Earth systems: *How can paleoclimates and weathering processes be related to past plate positions and plate tectonic events?*

Figure 1. *Laurentia at 535 Ma.*

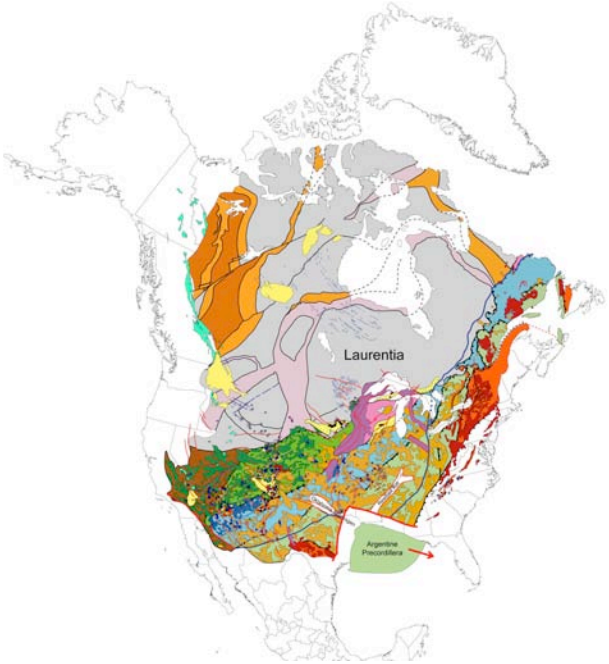
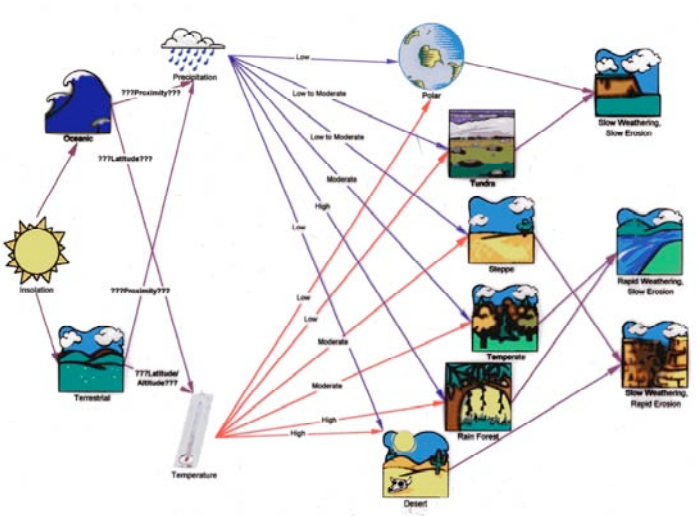
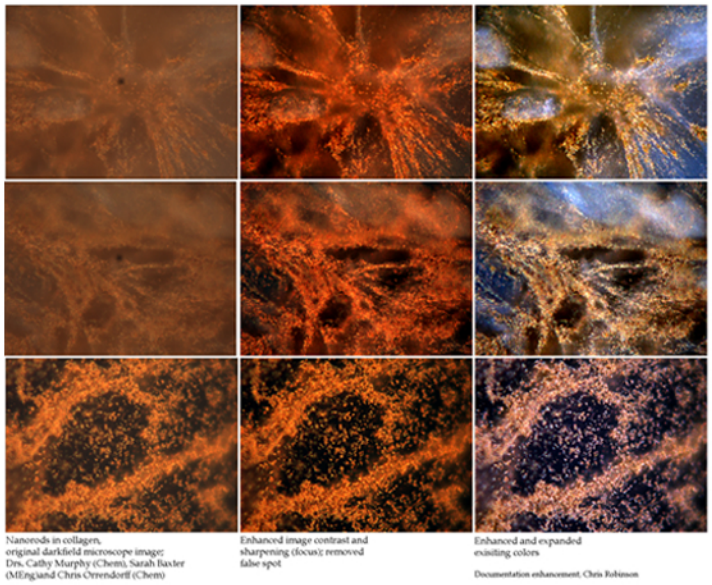


Figure 2. *Process Relationships of Climate and Physical Geology*

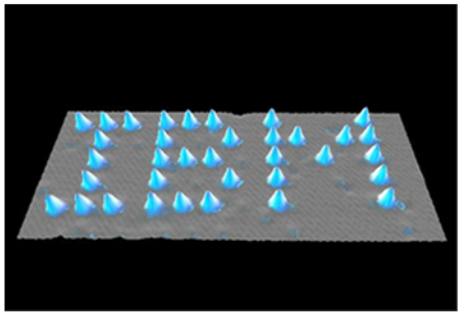


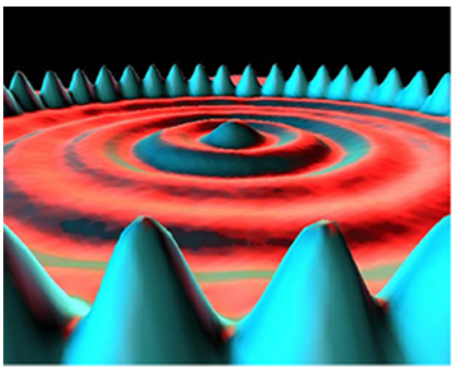
- **Chris Robinson**
- CTR@SC.edu
- Department of Art
  University of South Carolina
  Columbia, SC 29208

- Visual Art
- How can we have some influence on the reckless misinformation permeating visual representations of science and why is misleading and inaccurate imagery being characterized as good or enhancing science?
- How do you confirm visual representation at the nanoscale and will we find a way to bring this information into our perceptual realm?



Left - Robinson, 1992 Laser installation detail, SC Capitol, 2 miles - the installation creates a structure, attracts attention to the surrounding environment, and illuminates the nature of laser light.
Right - Robinson (S. Baxter - Mechanical Engineering, C. Murphy - Chemistry/Biochemistry, E. Goldsmith - Medicine), 2006 Darkfield microscope image composite of light scattered from gold nanorods embedded in a fibroblast seeded collagen gel; enhancing the image without altering the science.





June 2000 Scientific American cover. Award winning nanolouse, famous Don Eigler images of IBM and an Electron Coral these images may mislead more than they inform. Is it necessary and why do we compromise the informative aspects of the science while trying to make a beautiful image?

Image and Meaning 2006 Application

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Field of Expertise: Graphic Design and Information Science

GENERAL QUESTION

Can the ability to interact with visualizations of complex science content enhance the method by which users can access that content? Correspondingly, can this interaction enhance the amount of understanding a user can derive? For example, if several pieces of information are represented on a static graphic panel, and each piece addresses a different level of expertise, how does this layering of information change with the addition of interaction? Does hiding deeper levels of content by making the content accessible through interaction inhibit the viewer to access that content; or, instead, does this allow for more investigation?

SPECIFIC QUESTION

The challenge of aesthetics verses representation: How many dimensions of data should we represent in visualization of complex science content such as the multifaceted data in a visualization of cosmic ray showers? Is it more effective to use a limited color palette rather than a full color spectrum to distinguish elements in a visualization even if the limitation sacrifices levels of complexity in the data?

IMAGE EXAMPLES

A visualization can express different values of a variable using three properties of color: Hue, lightness/darkness, and saturation. Can these properties be automatically chosen to optimize for a general audience?

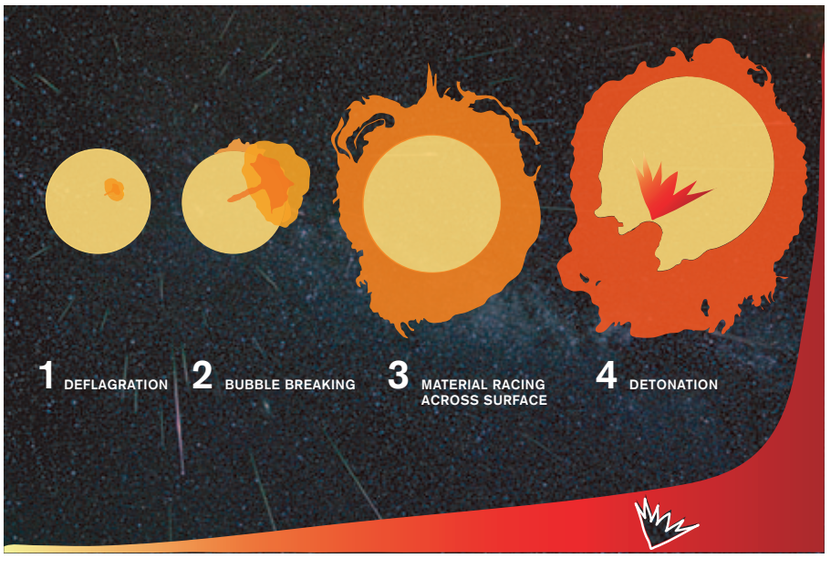

Image I shows a graphic of a supernova explosion using a limited variation in hue and a corresponding variation in lightness/darkness and saturation. The change in color can perceived by people with varying degrees of colorblindness.

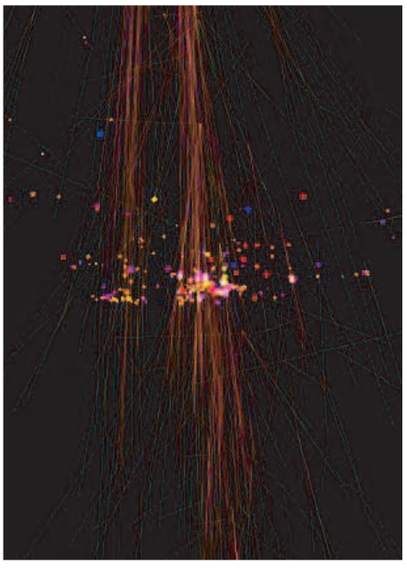

Image II shows a 3-dimensional visualization of particles in cosmic ray air where the variety of particle species create a large variation in the color representation of each particle. With an already diverse color palette, other information such as each particle's energy level cannot easily be expressed.

Rob Schick
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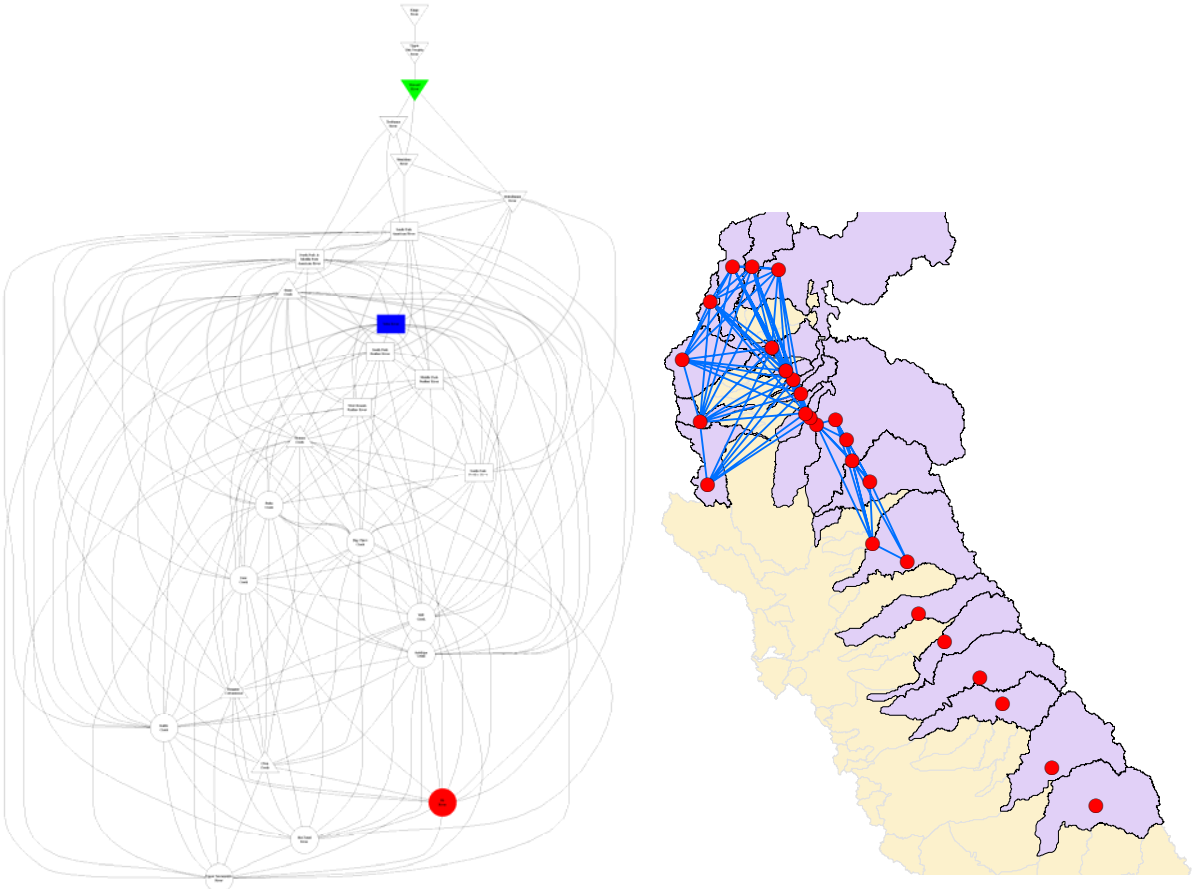
Field of Expertise: Marine Ecology, Spatial Ecology, Graph Theory

General Question
I am a Ph.D student in ecology and am broadly interested in connectivity: demographic, spatial, genetic, etc. Especially with regard to spatial connectivity (i.e. how habitat patches in a landscape are connected), I use graph theoretic techniques to represent that connectivity, and find that people often have difficulty visually transcribing connections in graph space to connections in geographic space and vice versa.

Specific Questions:
How does one represent a hypergraph, i.e. a multi-dimensional graph of graphs?
How does one represent multiple temporal dimensions across a graph?

Images:



The left image does a good job (though not at this scale) displaying the graph theoretic structure of fish populations that I research. However, the right hand image has the actual map that people are familiar with. My challenge is to marry the geographic space with the graph theoretic space.

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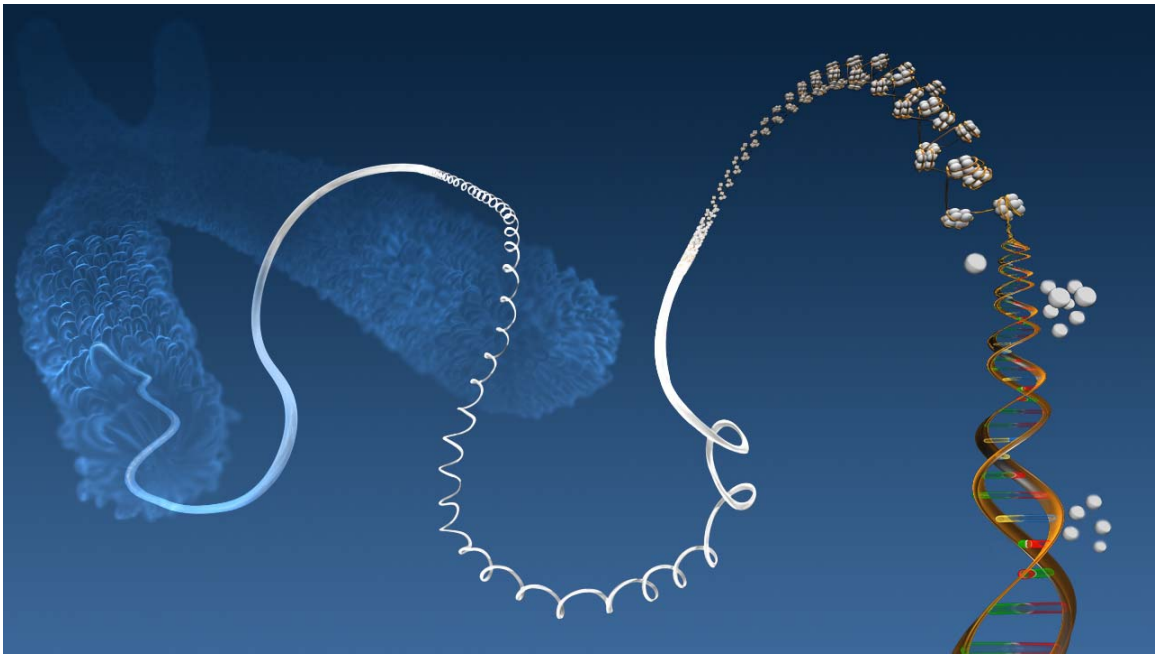
General question:
How would you show in a single graphic a group of objects with extreme variations in scale effectively? The objects are all connected. How would you create the flow from one magnification to another?



DNA Super coiling from the chromosome to the double helix

IM2.1 Submission

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Field of Expertise

Cognitive aspects of multimedia instruction; Integration of technology in instruction; Teaching scientific visualization in K-12 education.

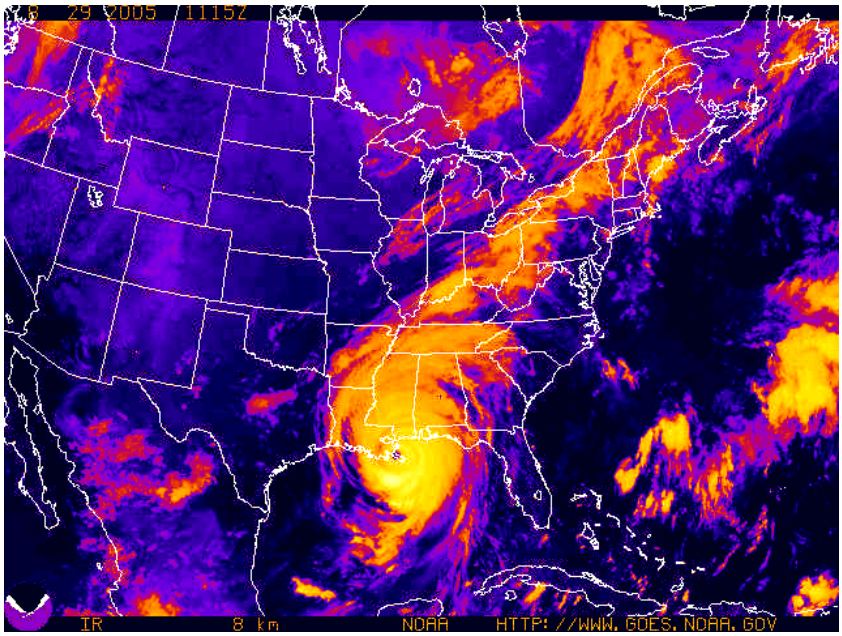
General Question

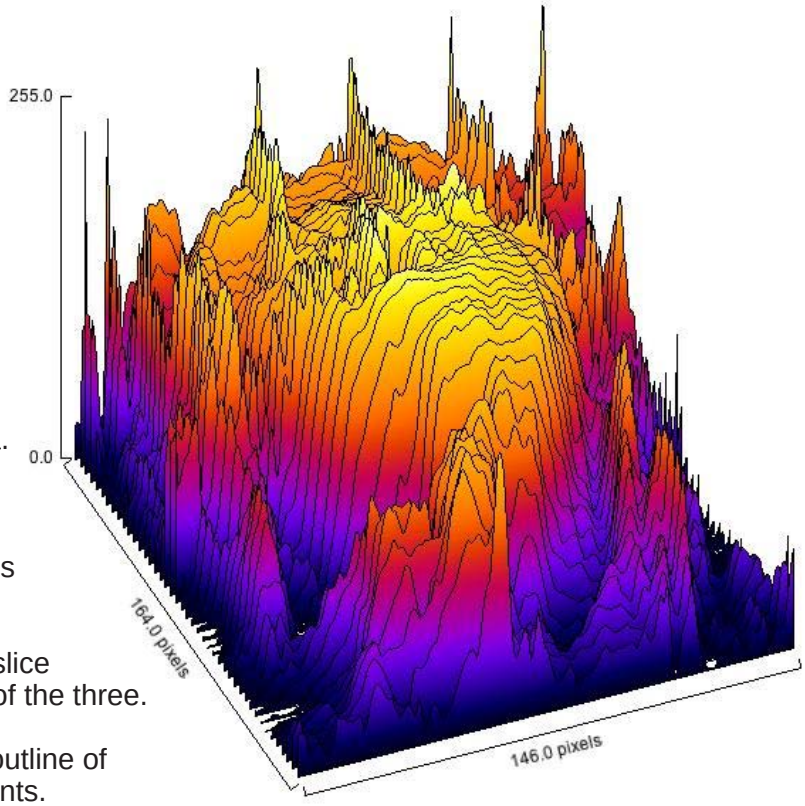
How do we determine the appropriate image representation given the instructional context and learner characteristics?

Specific Question

Weather is a popular topic for exploration in middle school science classes. Not surprisingly, exploration of severe weather events, such as hurricanes, are particularly popular. Remote sensing images are a powerful tool for investigating cloud characteristics such as temperature and altitude. Unfortunately, there are many possible ways to represent these data. For example, the top image allows students to see a “bird’s eye view” of the cloud cover, but requires them to translate color to temperature (and then to altitude). The middle image provides an indirectly generated 3-D shape of the clouds, but obscures a lot of data. The bottom image provides a very accurate representation of one slice of data, but is the most abstract representation of the three.

A secondary issue is how reference data (e.g., outline of the states) is interpreted by middle school students. While the state outlines, coded at value 255, is quite interpretable in the top image, it appears more like “noise” in the bottom two images.





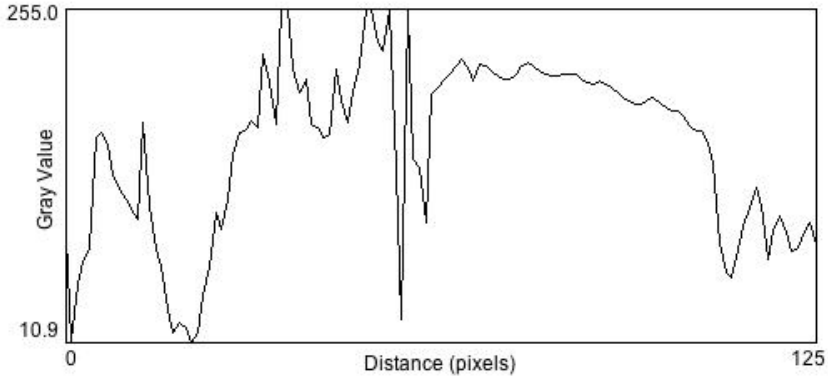


Image and Meaning 2.1 Application (Research Triangle Park, NC. June 2, 2006)

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Field of Expertise:
Ecology & Evolution; Philosophy of Biology.
Asst. Professor of Biology, School of the Art Institute of Chicago

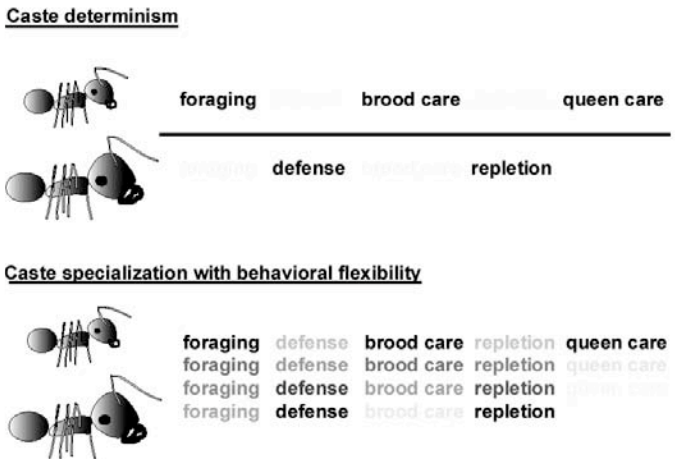
General Questions: How are complex biological concepts best communicated to non-professionals in an educational setting? To what extent should images for public audiences and those for professional audiences be divergent in format or content?

Specific Questions:
How are complex models of time-based biological processes, such as development and evolution, effectively communicated, especially when they involve multiple continuous variables?

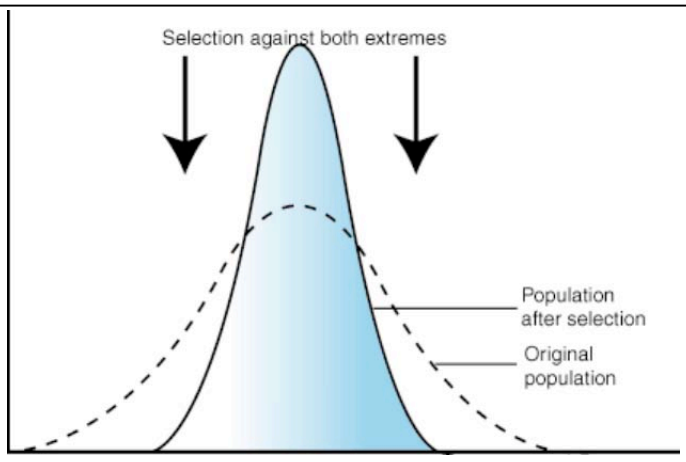
What is the efficacy of 2D vs. 3D representations of graphics involving a time dimension? What is gained and what is lost in terms of visual complexity and content?

What are the costs and benefits of using metaphorical (or hybrid metaphorical-concrete) visual models to convey complex scientific concepts? (e.g. Waddington's depiction of the "Epigenetic Landscape" ? Or the "evolutionary trees" of organisms?)

Two Models for the Relationship between Morphology & Behavior in Ant Castes



Promising Image: Meant to convey two general models of division of labor in ants, I've used this relatively simple graphic with some success both general and scientific audiences.



Problematic Image: Below is a textbook image of "stabilizing natural selection." Many students in the evolution course I teach complain that this graphic is confusing, although this manner of depicting change in a population variable (and related concepts) is standard within the professional community. What (besides axes label, etc.) is lacking in this representation? What is another more effective way to represent such dynamic processes?

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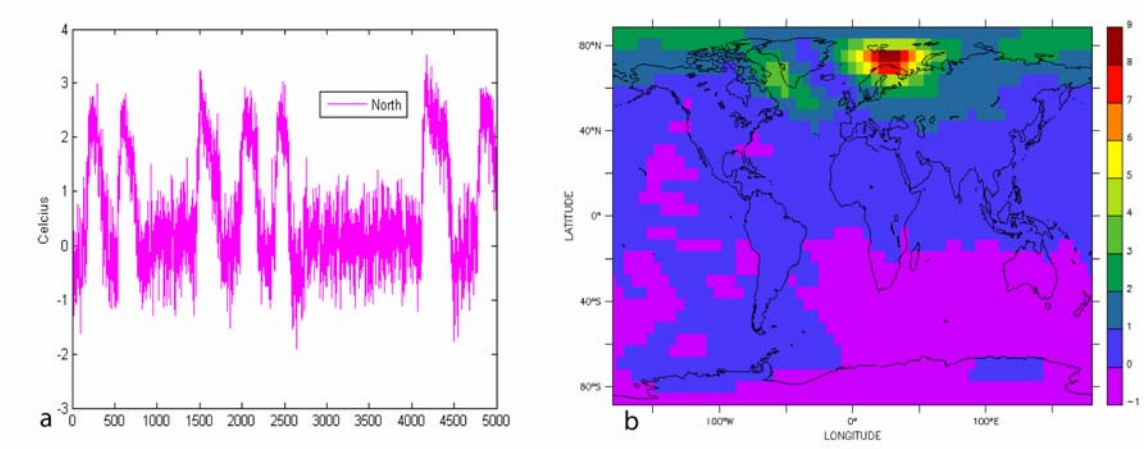
Field of expertise: Numerical modeling for global climate system. The abrupt climate changes during the last ice age. Modeling of the thermohaline ocean circulation.

General question: What is the best way to visualize the 4-D datesets (space and time) generated by the 3-D numerical global climate model?

Specific questions:

- What is the best available visualization tool to read the dataset in NetCDF format?
- In the presence of noises, how to find out when and where the abrupt climate changes take place initially?
- The abrupt changes happen in various climate variables and in the atmosphere and in the ocean. I would like to know if I can determine which variable the leading one or if the events happen first in the atmosphere or in the ocean by better visualizing the datasets?



In figure a, each spikes represents a warming event, emerging from the cold climate, in the northern North Atlantic. Figure b illustrates the air temperature anomaly between the warm and cold climates. The red spot is the maximum warming spot during the warming events. These two plots are generated from a single 4-D dataset by average over space and time, respectively. I am wondering if there is a way to express the 4-D data in a single plot and I can find out the timing and location of the beginning of the warming event simultaneously.