A Decade of BioScapes Competitions

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Introduction

The Olympus BioScapes International Digital Imaging Competition completed its tenth year in 2013. This important contest honors images of life science subjects acquired through light microscopes. Each year a distinguished panel of impartial judges selects winning entries on the basis of the science they depict, their beauty, and the technical merit they embody. The competition is open to users of any brand of microscope and camera. Winning images and movies often represent recent advances in neuroscience, cell biology, botany, zoology, and other biological disciplines. These images exhibit excellence in particular microscopy techniques, exceptional views of familiar objects, or cutting-edge examinations of the internal structure of organisms. Thus, the 10 prize-winning images and 60-odd honorable mentions represent examples of the best in bio-imaging each year.

The organization and implementation of the BioScapes competition are formidable undertakings. Typically each competition involves about 2,000 entries from more than 70 countries. Just to receive and handle this many entries in various image formats, shapes, and digital sizes is an enormous task. Each image or movie clip must be prepared in a standard manner for impartial judging. Information about both the identity of the photographers and the equipment used to capture images is withheld from the judges to make the judging as fair as possible. Once the winners are selected and announced, they are presented in the "Gallery" pages of the BioScapes website (www.OlympusBioScapes.com) in a beautiful, functional layout. The logistical details of the competition, the judging, and the website are handled expertly by Michael Davidson and his team at Florida State University.

In addition to the considerable publicity surrounding the winners, each year about 30 award-winning BioScapes images and movies travel to exhibition venues across the United States and around the world. Recent BioScapes exhibitions toured cities in the U.S., Canada, South America, Europe, and the Middle East. In 2014, exhibitions are being displayed at 12 research centers and science museums in 8 states.

This article presents several snapshots of the first BioScapes decade. The top prizewinners exhibit the best of each year. There are also specific subjects and trends that can be traced through the 100 prizewinners and 600 honorable mentions (HM) honored over the decade-long life of the competition.

Competition Judging

As mentioned above, each year's panel of four expert judges selects the winning images and movies on the basis of science, aesthetics, and technical merit. For the science criteria, the judges look for uniqueness of the specimen or process shown, importance of the work, new information revealed, and the "story" that is being told. Aesthetics criteria include the beauty or impact of the image, particularly its balance and composition. Assessment of technical merit considers the challenge of the specimen and the difficulty of capturing the structures or data shown, as well as photographic excellence.

For example, the 2013 first prize image by Dr. Igor Siwanowicz (Figure 1) exhibits excellence in all of the judging criteria. This image shows the open trap of an aquatic carnivorous plant, the humped bladderwort *Utricularia gibba,* with red areas depicting chlorophyll's innate fluorescence. The floating plant digests microinvertebrates that are sucked into its trap a millisecond after they touch its trigger hairs. The trap also

Figure 1: The 2013 First Prize image showing the open trap of an aquatic carnivorous plant, the humped bladderwort *Utricularia gibba* (Igor Siwanowicz).

provides a microhabitat for single-cell green algae, predominantly desmids, which are visible inside. Dr. Siwanowicz, who studies the neurology of hunting behaviors in dragonflies at Howard Hughes Medical Institute, Janelia Farm Research Campus, Ashburn, Virginia, came across the specimen while searching for dragonflies at a local pond. Not only is this image stunning to look at, it is also rare in that it is a microscope image that shows an interesting association between the bladderwort and the desmid algae.

Response to BioScapes

BioScapes is truly international. As Dr. Laura Ferguson, who spearheads the program for Olympus, tells us: "When Olympus started the BioScapes competition in 2004, our vision was that it would help shed light on the amazing stories being told in laboratories around the globe, and in the natural world as well. We have accomplished that. What we couldn't predict was how large and how quickly the competition has grown and how much it has focused worldwide attention on the vitally important work of scientists. BioScapes has piqued interest in science around the world and has helped inspire many young people to choose a career in science. It also has encouraged researchers to strive for excellence in microscopic imaging. It has surpassed even our most optimistic goals."

Background to the Images

The first BioScapes competition was held in 2004. This was an auspicious time for light microscopy. While bright field, dark field, polarized light, and differential interference contrast were standard techniques, an array of new methods had appeared. In the two prior decades, the incorporation of lasers and computers into light microscopes opened several new approaches to biological microscopy. In this period new confocal microscopes appeared on the market, and digital image control allowed images taken at incrementally different planes of focus in the specimen (*Z* stacks) to be collected for later combination into images exhibiting greater depth of field than ever before in a light microscope. In addition, development over the previous decade of genetically modified green fluorescent protein (GFP) and other fluorophores allowed the tagging of specific cellular components in a wide variety of organisms and plants. In multiphoton microscopy, energy from two or more infrared photons combine to excite the fluorophore. Use of long-wavelength infrared photons improves imaging depth in the *z* axis and reduces damage to the specimen. The fluorescence signal can be localized to a tiny volume, effectively suppressing the interfering effects from out-of-focus specimen regions and allowing imaging deeper into the specimen. The application of digital imaging to video images allowed high-quality movies of biological processes. In the last few years this capability has improved markedly [1–3].

Most of the images from the first decade of the BioScapes competition employ these and other techniques from the cellular level up to the imaging of entire organisms. Tagging of specific organelles, localization of signal generation, and increased depth of imaging have opened new biological landscapes to explore, and the images of this period dramatically improved our understanding of biological structures, their functions, and their development. Other important technologies, such as hybrid microscopy, intravital specimen imaging, and the capture of large image areas using whole slide imaging and/or tiling are also represented among the winners and honorable mentions.

Many BioScapes images reflect important research studies. Some of the areas represented include stem cell studies, whole organ imaging, and brain mapping, along with research into breast cancer, ALS, HIV, neurofibromatosis, crop failure, eye disease, and more. In the natural world, BioScapes images reveal the wonders of such specimens as pond life, insects, mollusks, common plants, and weeds.

Top Prize Winners

The images that have earned first prizes over the past 10 years exhibit a wide variety of techniques and subjects. Figure 2 shows a composite of these winners. Further details about any of the images mentioned in this article can be found in the BioScapes Gallery at www.OlympusBioScapes.com. For a retrospective such as this, individual image sizes must be restricted; however, these images are spectacular when viewed at full size. Thus, to fully appreciate these images, it is recommended that they be viewed at the above website.

The impact of confocal microscopy throughout the decade is evident in that 7 out of 10 first-prize-winning entries were captured using confocal microscopes. It also is interesting to note that the first three years of top winners (2004–2006) all depict images of parts of the eye. In another interesting coincidence, the 2011 and 2012 winners both show cilia of rotifers, but the winner in 2012 was a movie showing rapidly beating cilia in a rotifer colony. Both of these examples of rotifer imaging used differential interference contrast, showing that older techniques still can produce excellent images containing valuable information.

Images of Organisms, Tissues, and Cells

Extracting images with certain common threads from the 700 images and movies designated as winners or honorable mentions is not a trivial task. Because several techniques were used in these images, one theme is the type of microscopy used in image acquisition. The following figures show selected examples of stereomicroscopy, confocal microscopy, fluorescence microscopy, and movies taken through the microscope. Other themes relate to subject matter: Drosophila, mouse organs, human tissues and cells, and the motions of small plants and organisms.

Stereomicroscopy at magnifications of 2× to 70× provides close-up views of familiar objects that may be seen, but not really understood, with the naked eye. Figure 3 shows a seed from the American elm, an amphipod crustacean, an acorn weevil, and a cross section through agatized dinosaur bone. Color in these images was natural except where polarized light was employed.

Confocal microscopy appears to be the technique of choice for common lab organisms and various types of tissue. Figure 4 shows different features of *Drosophila* (fruit fly) adults and larvae stained with fluorescent proteins or fluorophores conjugated to antibodies. Confocal microscopy is typically combined with the tagging of specific cellular

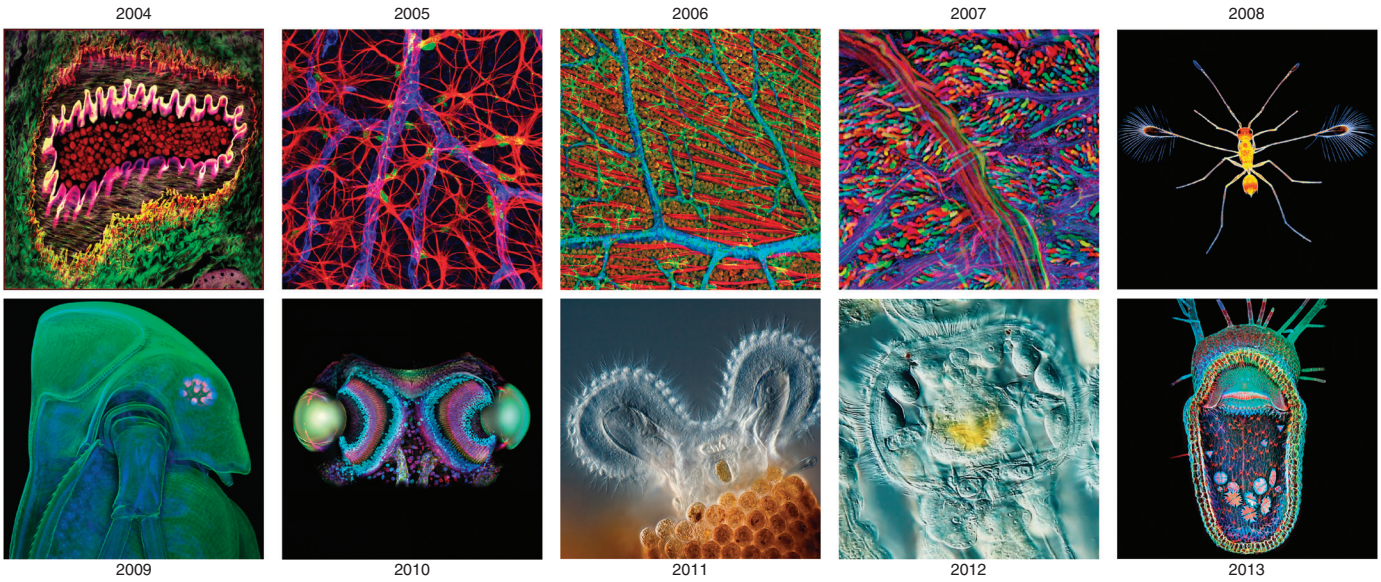

Figure 2: First-prize winners. **2004:** Healthy arteriole in the eye, with tough, flexible elastin wall (pink), red blood cells (red), and supporting collagen fibers (web-like netting); confocal (Donald Pottle). **2005:** Retinal astrocytes; confocal (Hussein Mansour). **2006:** Mouse retina; confocal (Thomas Deerinck). **2007:** "Brainbow" mouse brain stem; confocal (Jean Livet). **2008:** "Fairy fly" wasp, Rheinberg illumination (Spike Walker). **2009:** *Daphnia atkinsoni* showing "crown of thorns" defense trait; confocal (Jan Michels). **2010:** Eyes of Daddy Longlegs (Harvestman); confocal image stack (Igor Siwanowicz). **2011:** Rotifer *Floscularia ringens* feeding; differential interference contrast (Charles Krebs). **2012:** Screen capture from a movie of colonial rotifers showing eyespots and corona; differential interference contrast (Ralph Grimm). **2013:** Open trap of aquatic carnivorous plant *Utricularia gibba* with single-cell organisms inside, chlorophyll fluorescence (red); confocal (Igor Siwanowicz).

Figure 3: Stereomicroscopy. Clockwise from upper-left: American elm *Ulmus americana* seed, polarized light (Edwin Lee, 2010 HM); amphipod crustacean from the sea floor near Antarctica (Gregory Rouse, 2013 HM); agatized (silicified) dinosaur bone from the Morrison Formation in Utah (Douglas Moore, 2013 HM); acorn weevil *Curculio glandium* (Csaba Pintér, 2013 HM).

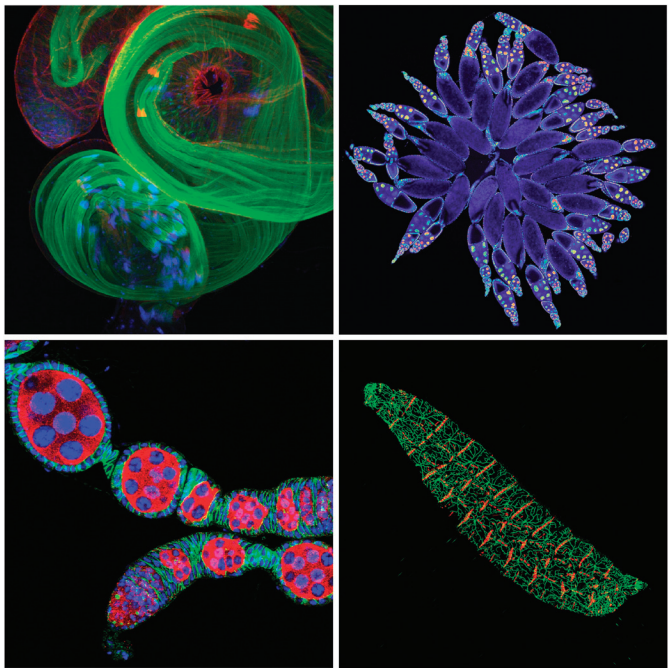

Figure 4: *Drosophila* specimens. Clockwise from upper-left: *Drosophila* sperm, confocal (Janet Rollins, 2011 HM); *Drosophila* ovary, confocal (Denise Montell, 2011 HM); *Drosophila* larva, confocal (Chun Han, 2010 HM); *Drosophila* ovarioles, confocal (Daniel Kirilly, 2004 HM).

components to produce fluorescence in specific colors to delineate organelles or macromolecules within cells. Figure 5 shows various organs in the adult mouse. These images are primarily produced using fluorophores, which may be complexed to other molecules, or fluorescent proteins. The Brainbow image is produced by the use of specific fluorescent proteins. The gene for the fluorescent protein is "attached" to a target gene within a specific cell type, so that when the target gene's protein is synthesized, it includes the fluorescent protein.

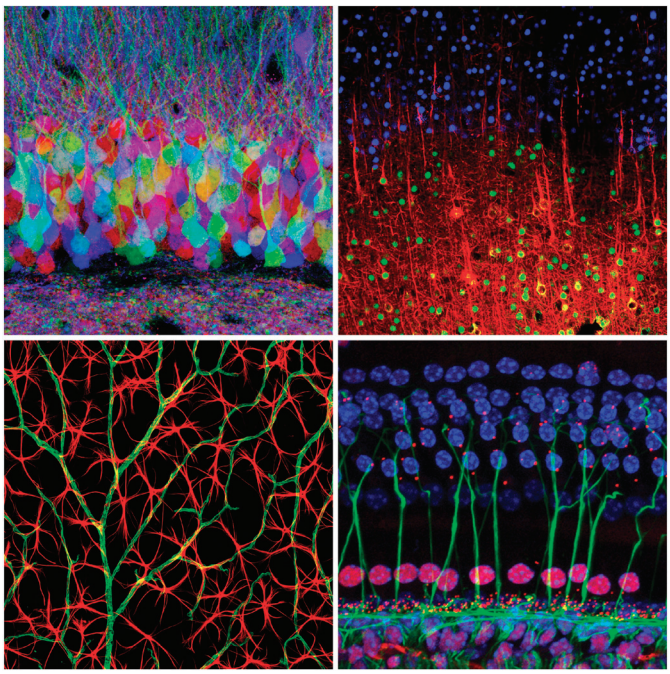

Figure 5: Mouse organs. Clockwise from upper-left: "Brainbow" image of neurons in the mouse hippocampus, confocal (Jean Livet, 2007 HM); mouse cerebral cortex, Layer V neurons (red), their nuclei (green), confocal (Claudia Barros, 2013 HM); mouse organ of Corti, part of the inner ear, confocal (Tyler Hickman, 2013 HM); mouse retina, astrocytes (red) and blood vessels (green), confocal (Gabriel Luna, 2011 HM).

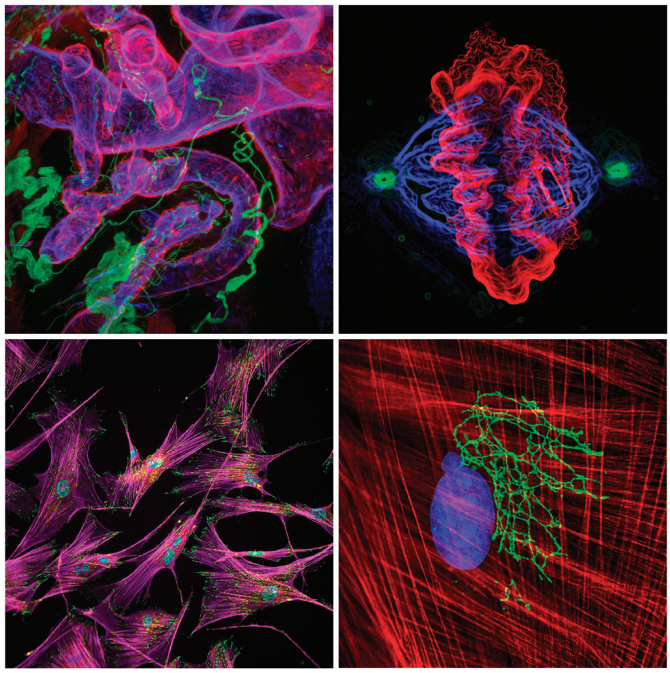

Figure 6: Human cells and tissue. Clockwise from upper-left: human small intestine, blood vessels (red, purple), nerves (green), confocal (Mona Selim, 2007 HM); human epithelial cell in mitosis, fluorescence and decovolution (Joshua Nordberg and Christopher English, 2004 HM); HeLa cell, confocal (Tomasz Szul, 2006 HM); human lung fibroblasts showing intracellular proteins, epifluorescence microscopy (Ankur Singh, 2013 HM).

What is unique about Brainbow is the way it enables individual brain neurons to be distinguished from one another. Neurons randomly express a multitude of different colors, making it possible to flag each neuron with a distinctive color and follow its pathway through brain tissue.

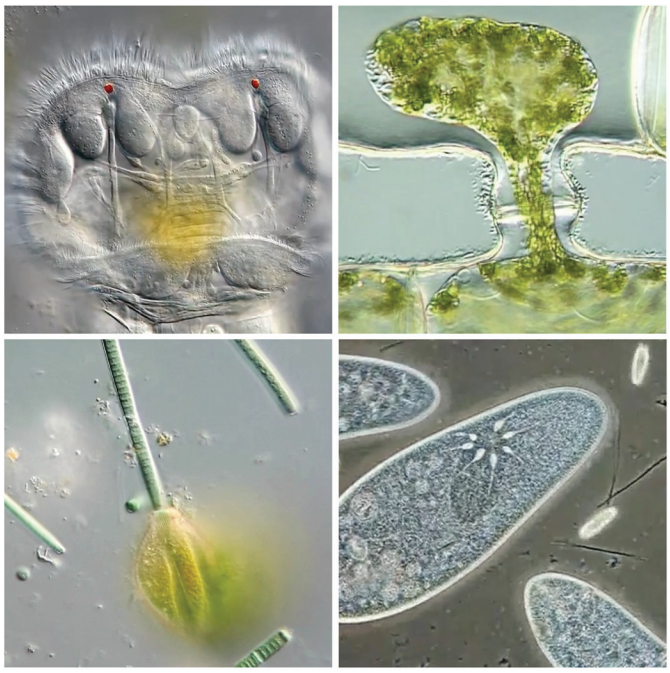

Figure 7: Screen captures from movies. Clockwise from upper-left: colonial rotifers showing eyespots, differential interference contrast (Ralph Grimm, 2012 First Prize); sexual attraction in *Spirogyra*, brightfield (Jeremy Pickett-Heaps, 2009 Third Prize); *Paramecia* contractile vacuoles, phase contrast (Edwin Lee, 2011 Fourth Prize); ciliate *Nassula sp.* feeding on a cyanobacteria filament, differential interference contrast (Gerd Günther, 2013 HM).

Confocal and fluorescence microscopy also highlight human cells and tissues as shown in Figure 6. The color in these images is produced by the same mechanisms, and such images also illustrate how structures are visualized. The detectors of confocal microscopes are typically monochrome photomultiplier tubes, and each fluorophore's signal is collected in its own channel. The investigator then provides the specific colors for each channel. Usually, the colors assigned will be the color the fluorophore produces, but this is not always the case. Ankur Singh's 2013 honorable mention image of a human lung fibroblasts is a good example of this. The different structures are clearly shown and an aesthetic image is produced by choosing an atypical color palette.

Movies

From the earliest years of the competition, judging panels have always recognized extraordinary movies captured through microscopes, along with animated reconstructed images. The quality of these images has improved considerably over the decade as digital video photography became better and less expensive. Figure 7 shows several movies that depict organisms and cells carrying out normal life processes. Over the years, movies have captured movement using every microscope technique, depicting events as varied as plant root growth, rapidly streaming blood cells, a coral eating, plant reproduction, meiosis in spermatocytes, zebrafish embryo development, a deep dive into the whisker-controlling regions of a mouse brain, T-cells fighting off invader cells in a living mouse, and fungus erupting out of a blueberry.

Conclusion

The Olympus BioScapes International Digital Imaging Competition has chronicled a decade of important strides in life science photography through the microscope. These images also show that the development of new techniques does not mean that older methods—some over a century old—are no longer useful. Sometimes, the older methods are the better ones. That said, with advances in microscopy methods still proceeding at a significant pace, the next decade should be even more exciting.

Editor's Note: The deadline for the 11th annual Olympus BioScapes International Digital Imaging Competition is September 30, 2014. The top prize is $5,000 worth of Olympus equipment. To enter, or for more information, visit: www.OlympusBioScapes.com.

Acknowledgement

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References

[1] MW Davidson and M Abramowitz, *Optical Microscopy*, republished online 2012, available for PDF download at http://www.olympusmicro.com/primer/opticalmicroscopy.html.

[2] J Pawley (ed.). *Handbook of Biological Confocal Microscopy*, 3rd ed., Springer, New York, 2006.

[3] RL Price and WG Jerome (eds.), *Basic Confocal Microscopy*. Springer, New York, 2011.

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