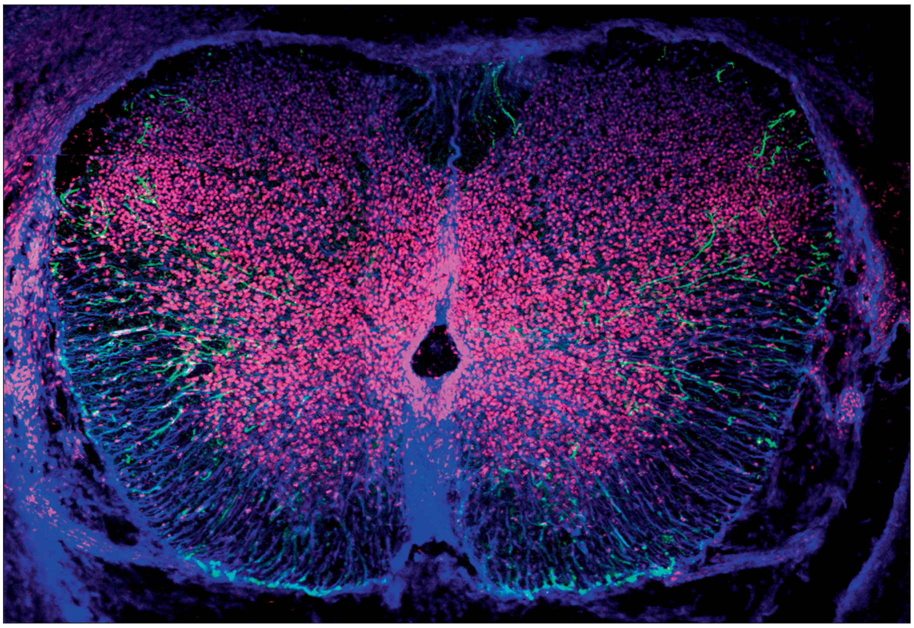


17

Fluorescence Microscopy of the Spinal Cord

Kieran Mc Dermott and Denis Barry

This is a study of the growth of the spinal cord, tracking the growth and distribution of three proteins: nestin; a protein abbreviated GFAP; and one called vimentin.

Confocal microscopy

In the course of the Study, we make use of several of the major techniques of contemporary light microscopy, including polarizing and fluorescence.

The technique used here is *confocal microscopy.* The microscope uses lasers to excite fluorophores ("labels" — chemicals that glow) in the specimen at selected levels. The microscope focuses on one layer at a time, collects the light from it, and moves on. The images are "stacked" to form a single image. That way the confocal microscope avoids a problem that plagues light microscopy — a very shallow depth of field.

The technique is very sensitive, and can be used on living tissues. The individual images are very faint (and very beautiful). Together they create an image unlike any conventional photograph — an image with potentially unlimited depth of field.

Gross atonomy

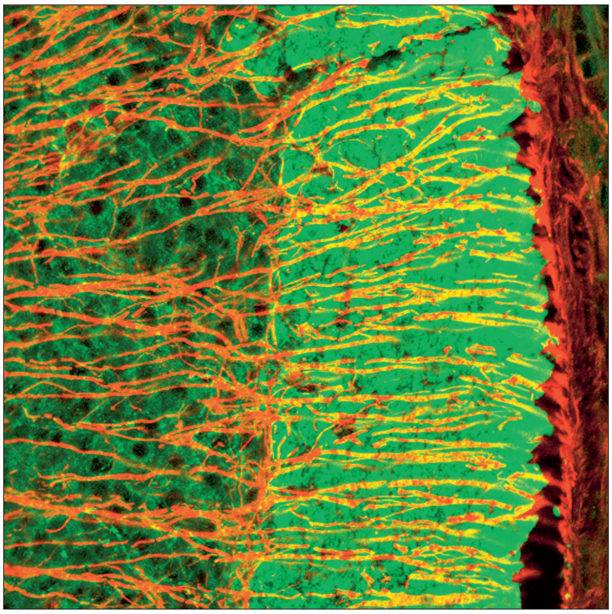
In the opening image, the spinal cord is shown in cross-section. The grey matter is at the center. Around the edges is the white matter, which appears darker here.

The colors

The grey matter is labelled with propidium iodide, which glows a livid magenta when it is illuminated by a yellow laser at 568nm. The protein vimentim appears as blue fibers, and the protein GFAP appears as green fibers, both in the white matter. The red areas show the presence of the label Cy5, which gloes when it is illuminated by a 647nm (far red) laser. The experiment uses three lasers simultaneously for red, green, and blue fluorescence.

The experiment

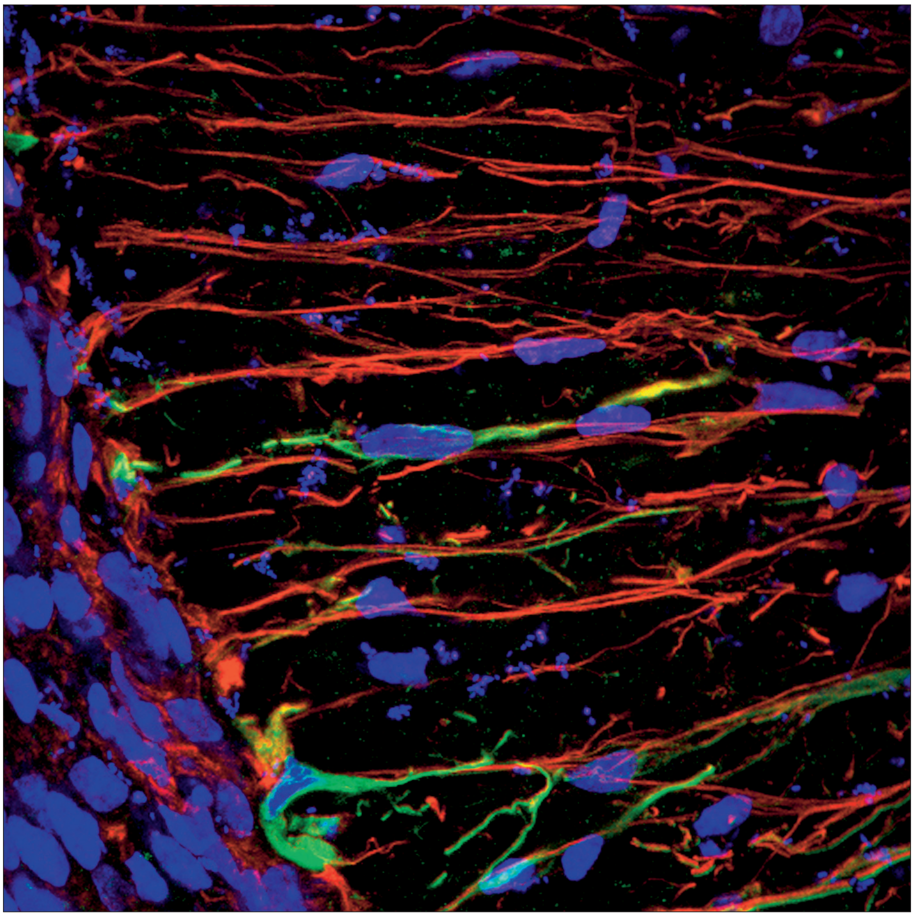
This is a high-magnification detail of part of a spinal cord. (Compare with the opening photo.) Here long fibers of the protein nestin appear stained an orange-red. They can be seen coursing out of the grey matter of the spinal cord (at the left) and into the white matter.



On the next page is another high-magnification image. Here we are interested to observe that the green fibers contain the protein GFAP, it seems to be originating from cell bodies, which glow blue because they are labeled with propidium iodide. And as before, the red fibers contain the protein vimentin, and glow red because they are labeled with Cy5.

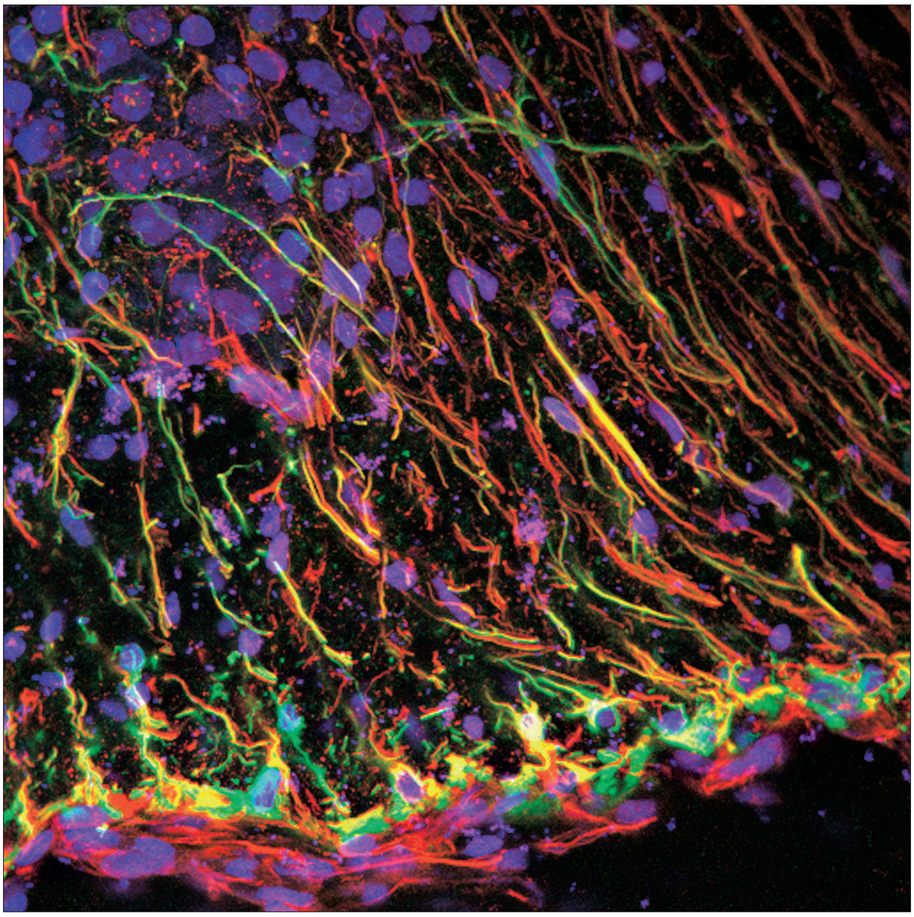
Strength and limitations of confocal microscopy

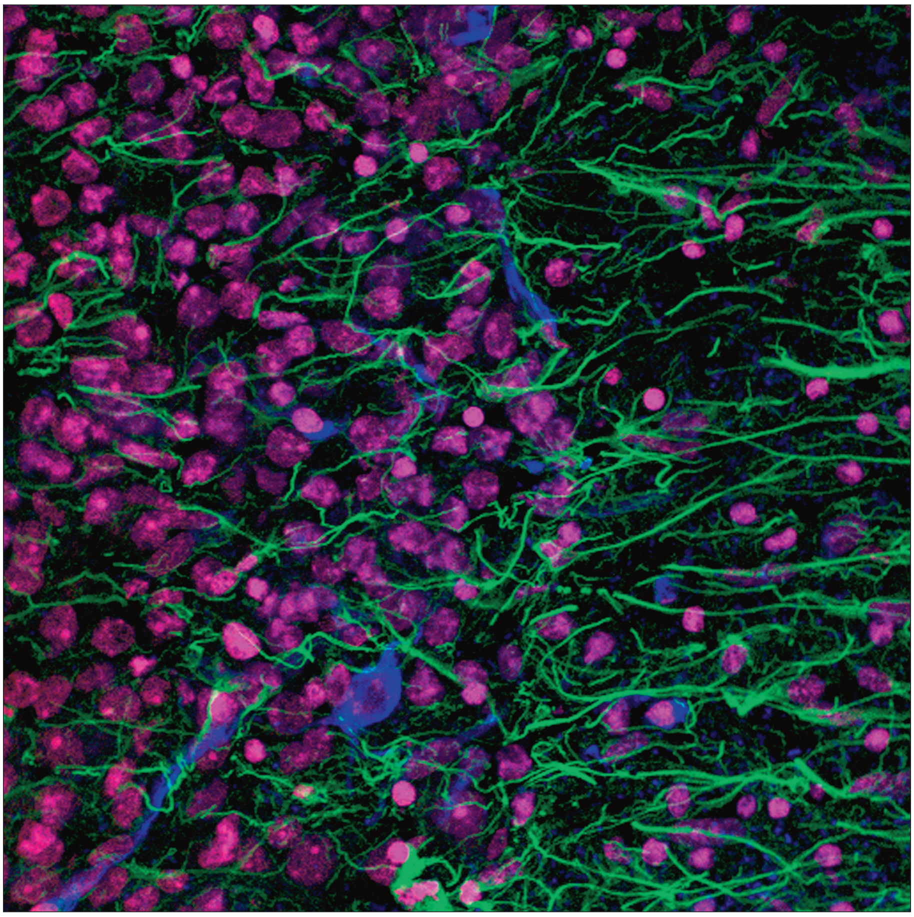
The technique is limited in several ways: confocal microscopy is time consuming and expensive, and the lasers tend to bleach the fluorescent dyes in the specimen.



Otherwise the technique is perfectly adequate to its purpose: the high resolution and spectacular clarity offered by confocal microscopy, combined with multi-antibody labeling methods, allows a four-dimensional reconstruction of the dynamic processes occurring in the developing spinal cord.

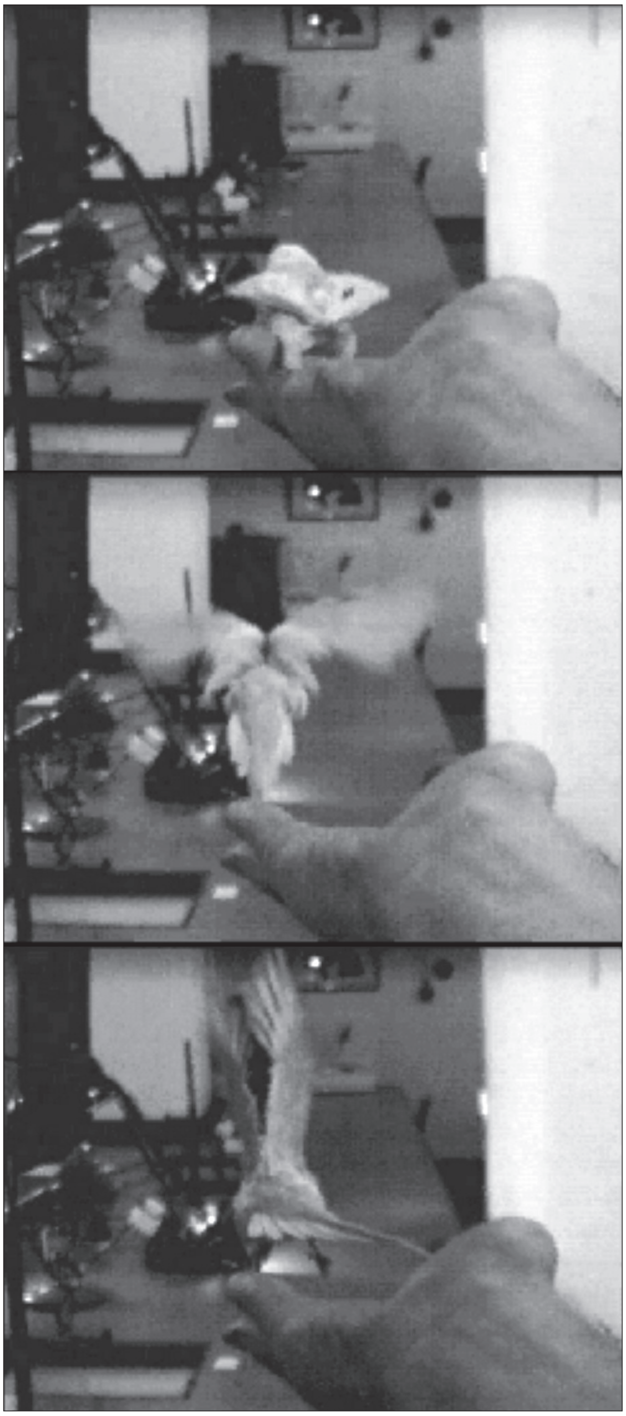
Confocal microscopy presents pictures in "false color," and it presents single pictures that are actually composites of many images. The same is true in a number of fields (see Chapter 16, for example, where the subject is aerial photographs). Confocal microscopes are one of a group of electron- and light-microscope technologies whose purpose is to enhance the contrast of thin, translucent organic materials. Chapter 21 lists some others, and electron-microscope techniques are described in chapter 27. Together these technologies comprise a group of allied practices, with common elements and overlapping strategies for image production and interpretation (see the Introduction for the full form of this argument).





For further reading

S.C. Noctor, A.C. Flint, et al, "Neurons Derived From Radial Glial Cells Establish Radial Units In The Neocortex," *Nature* (February 8, 2002): 714-720; M. Oudega and E. Marini, "Expression of Vimentin and Glial Fibrillary Acidic Protein in the Developing Rat Spinal Cord: An Immunocytochemical Study of the Spinal Cord Glial System," *Journal of Anatomy* 179 (December 1991): 97-114; H.Y. Yang, N. Lieska, et al., "Immunotyping Of Radial Glia and Their Glial Derivatives During Development of The Rat Spinal Cord," *Journal of Neurocytology* 22 no. 7 (July 1993): 558-71; G. Chanas-Sacre et al., "Radial Glia Phenotype: Origin, Regulation, and Transdifferentiation," *Journal of Neuroscience Research* 61 no. 4 (August 15, 2000): 357-63; Barry and McDermott, "Differentiation of Radial Glia From Radial Precursor Cells and Transformation into Astrocytes in The Developing Rat Spinal Cord," *Glia* (Jan 28, 2005). For light- and electron microscope techniques in this context, see Elkins, *Six Stories from the End of Representation* (Stanford: Stanford University Press, 2007)



18

Ground Effect and Bird Flight

Marc Shorten

These frames are from a test film, part of an experiment to determine how bird flight works when the bird is close to a surface like water (or a table). The phenomenon under study, *ground effect* (GE), causes a wing to experience increased lift and decreased induced drag when it flies close to a surface. For GE to occur flight altitude must be on the order of one wingspan or less over a surface; the effect is often best exploited over calm water because of its smoothness relative to land.

The effect on different birds

Large sea-birds (Phalacrocoracidae, for example cormorants and shags), pelicans (Pelicanidae), albatrosses (Diomedeidae) and many species of waterfowl (for instance Eider duck, which are Anatidae, *Somateria mollissima*) regularly fly in ground effect to reduce locomotion costs. Little work has been done to compare GE flight behaviour or aerodynamics between species.

Induced drag

The largest component of GE is a reduction in *induced drag*, the slowing force associated with lift production, i.e. staying airborne). Exploiting GE is particularly beneficial for large birds because induced drag increases with the square of mass. For example, when a wing is 0.22 wingspans above a smooth substrate only about 25% of normal induced drag is experienced. This drag reduction is primarily as a result of decreased downwash off the wing, as air is forced parallel to the ground and the formation of wing-tip vortices is disrupted.

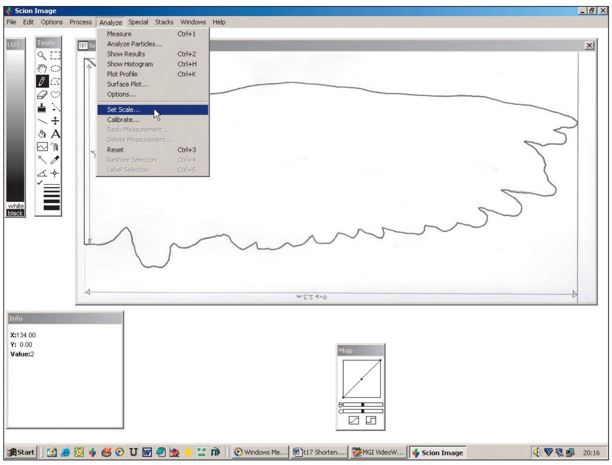
This project involves field observations using standard and high-speed digital video. Proportional numbers of flights observed in and out of GE are calculated from these data for a variety of species. These data are examined in the light of morphological and environmental data associated with the behavioural observations.

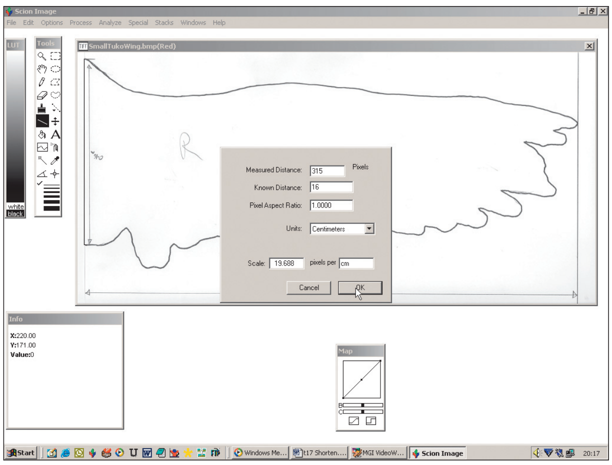
Measuring the birds' wings

This is a wing-tracing of a male Peregrine Falcon (*Falco peregrinus*).

The tracing is saved as a Bitmap file and scaled down in size to allow it to be viewed in totality on the screen. Then the picture is opened in an image analysis package (*Scion Image* Beta Version 4.02) so that the wing area can be measured. (More on why we're doing this in a moment.)

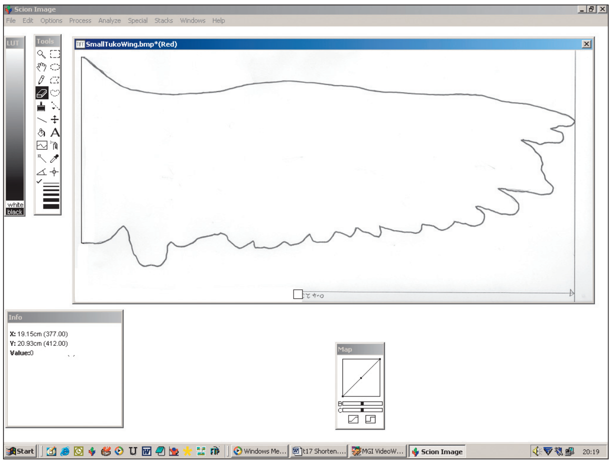
The initial task is to set the scale so that a given number of pixels corresponds to a given number of centimeters. This is achieved by drawing a line along a known distance on the wing (in this case, 16cm, the width of the wing where it meets the bird's body). The software automatically gauges the length of the line in pixels and thus, when the user tells it how to, the software converts pixels to centimeters.

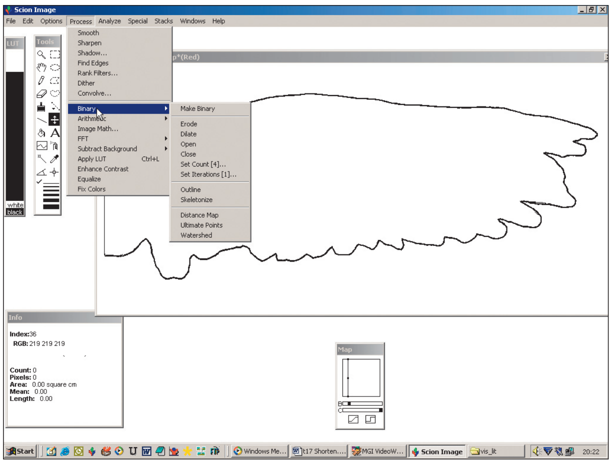


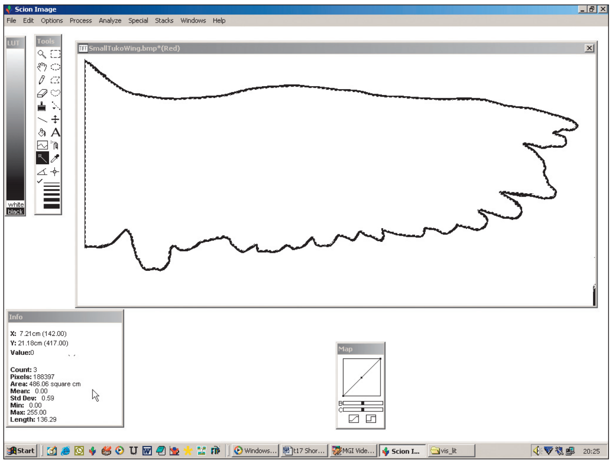


Once this is done, the picture must be cleaned of extraneous detail that the software could mistakenly regard as relevant. This is done by erasing everything in the picture except the outline of the wing. To further simplify the image the image is converted to a binary format where everything is either black or white (Bottom photo).

Using the magic wand tool the outline of the wing and nothing else is selected. Using the Measure function on the software, the area of the outline is then simply read from the screen. The cursor points to this in the photo on the next page. Knowing the full wingspan of the bird, the area of both wings and the section of body in between is easily calculated. Adding all of these together gives the total lift-producing wing area. This is one of the most important characteristics of a bird's flight anatomy.







Videos in the lab

The Budgerigar (*Melopsittacus undulatus, a kind of parakat*) was studied in the laboratory. A high-speed video camera recorded its flight. (The three frames shown here were a test flight, made to see how the camera worked. The result was lovely, unquantifiable footage, which flickers like an old Lumière Brothers film.)

The use of reference nodes (shown on the next page as red dots) allows demarcation of identifiable body parts in each frame. This, in turn, means that descriptions of flight behaviour may be brought beyond the verbal, using mathematics and coordinate geometry to make description more robust and less subjective. Each frame here is only 0.004 seconds in duration.

The footage is filmed with a grid in the background as a measure of the scale. In the computer, relevant parts of the bird's body are assigned colored nodes (they are red in the video). In this example, the nodes are the wing-tip, the carpal bend (the "wrist" of the wing) and the eye. In the video loop it's possible to see, for example, how when slowed down the top and the bottom of the wingbeat sequence may be compared with ease and accuracy. This is done by superimposing one image of the bird over a previous image. Given that the eye's reference node doesn't move relative to the rest of the body, the superimposition can be done by lining up the eye in the two pictures.

Each frame of the video is studied using node coordinates, allowing the motion of the nodes to be graphed.

Quantifying flight

The nodes are used to measure several things: wingbeat frequencies, wingbeat amplitudes, and whole-body air-speeds.

In this example, the coordinates of the nodes are used to estimate the bird's speed in meters per second (ms^{-1}), the vertical displacement of the wing-tip in meters (m) and the frequency of the wingbeat in hertz (Hz).

The image below shows shows x and y coordinates for body parts of the bird during a flight sequence captured on video. Thus, from only 0.072 seconds of video we know this bird flew at $6.85ms^{-1}$, with a wingbeat amplitude of 0.36m and a wingbeat frequency of 19.23Hz.

In themselves, these curves allow a geometric representation of the main characteristics of this sequence of bird flight. In the broader scheme of things such graphs allow comparisons of different birds, or even the same bird under different conditions such as changes in air temperature, air pressure or wind speed, or even factors like body mass, wing shape etc. There are established mathematical models of expected flight behaviour based on anatomical measurements such as those outlined above.

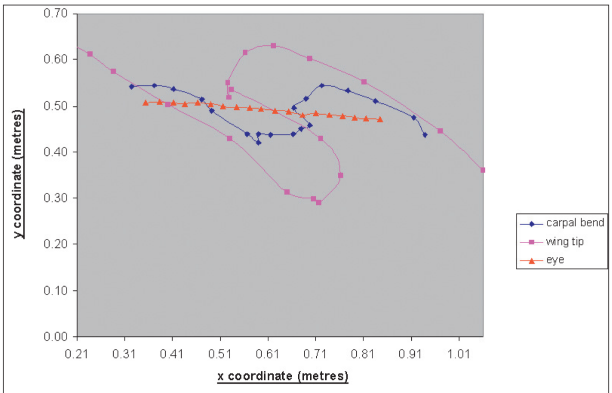


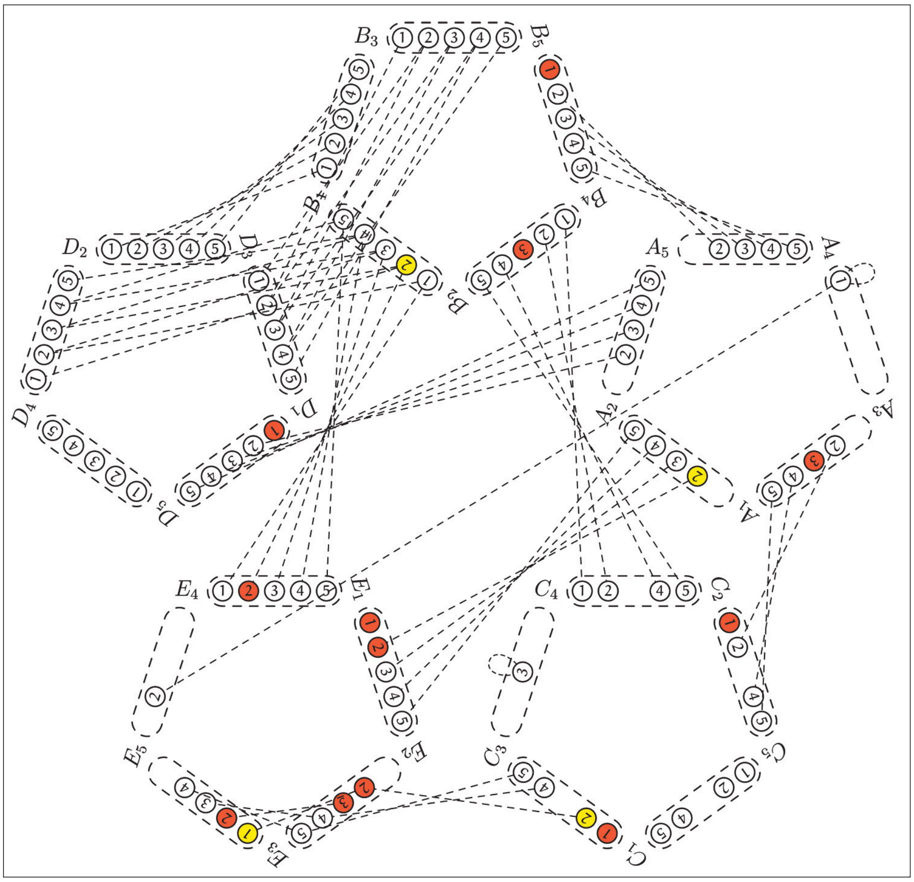
Figure 1. Location of Eye, Carpal Bend & Wing Tip in successive frames of video. Time elapsed between points is 0.004s. Coordinates given in metres.

Ground flight modelling

The ground effect modelling here was developed using behavioral, morphological and experimental data, as well as the bird-flight aeronautical theory and programs of Colin Pennycuick. This software makes it possible to compare actual observations of speed and wingbeat frequency with the expected figures for a species in ground effect. The software has been developed in such a way that it can be modified as the data are refined in the course of the research.

For further reading

Colin Pennycuick, *Bird Flight Performance: A Practical Calculation Manual* (Oxford: Oxford University Press, 1989); Pennycuick, *Measuring Birds' Wings for Flight Performance Calculations*, second edition (Bristol: Boundary Layer Publications, 1999); see also www.ucc.ie/research/mshorten.



A_1	Englishman
A_2	Spaniard
A_3	Irishman
A_4	Nigerian
A_5	Japanese
B_1	go
B_2	cricket
B_3	judo
B_4	poker
B_5	polo
C_1	coffee
C_2	tea
C_3	milk
C_4	orange juice
C_5	Guinness
D_1	dog
D_2	snails
D_3	fox
D_4	horse
D_5	zebra
E_1	red
E_2	green
E_3	ivory
E_4	yellow
E_5	blue

19

Solving the “Zebra Problem”

Marc Van Dongen

The problem, which may have originated with Lewis Carroll, is this:

> There are five houses of different colors,
> inhabited by people from different nations,
> with different pets,
> different drinks, and
> different sports.

There are fourteen more clues:

1. The Englishman lives in the red house.
2. The Spaniard owns a dog.
3. The man in the green house drinks coffee.
4. The Irishman drinks tea.
5. The green house is to the right of the ivory house.
6. The Go player owns snails.
7. The man in the yellow house plays cricket.
8. The guy in the house in the middle drinks milk.
9. The Nigerian lives in the first house.
10. The judo player lives next to the man who has a fox.
11. The cricketer lives next to the man who has a horse.
12. The poker player drinks orange juice.
13. The Japanese plays polo.
14. The Nigerian lives next to the blue house.

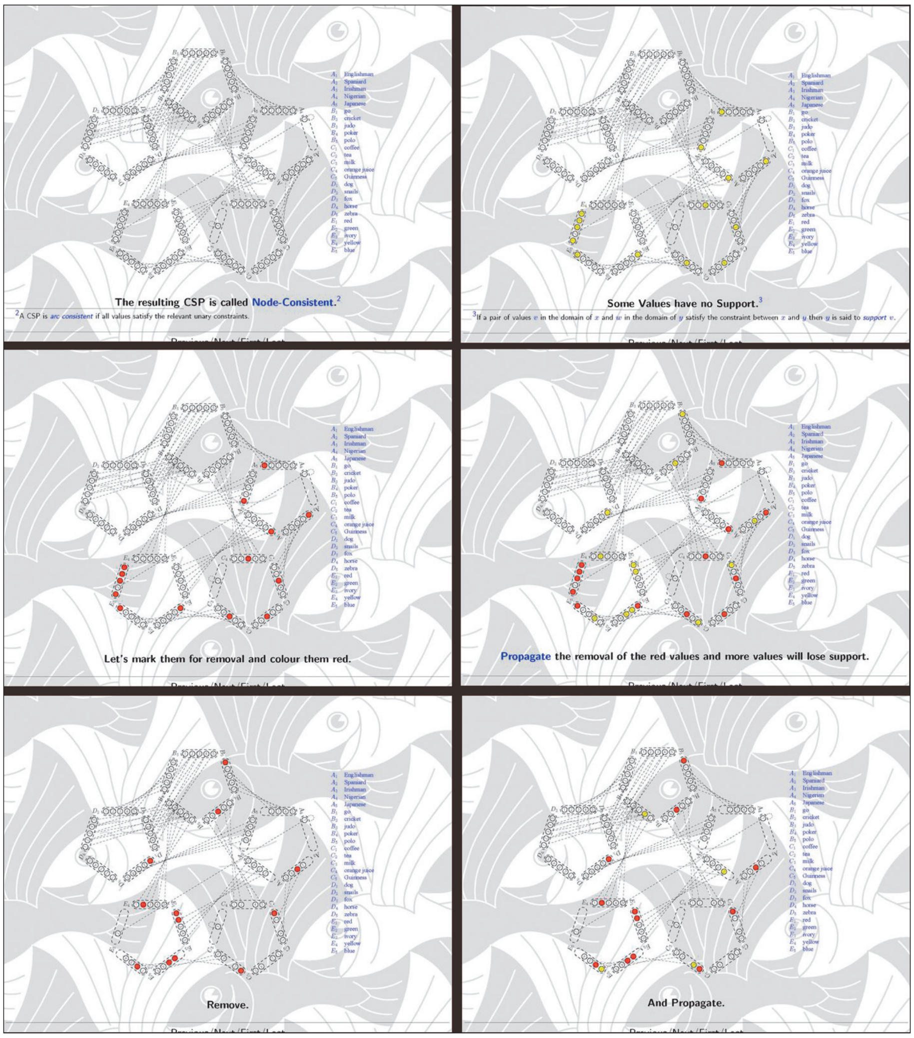
The question is:

> Who owns the zebra and who drinks Guinness?

The technique

It's a textbook problem for computer science students taking logic programming, constraint satisfaction, or artificial intelligence. In the exhibition that preceded this book, the solution was given in a PowerPoint presentation, involving fifty steps.

The fifty slides — some of them shown here — almost completely mimicked what a constraint-based solver (on a computer) would do, without images, in order to solve this problem. An important ingredient of such solvers is that they use the constraint between the variables in the problems, together with simple



reasoning, to remove values from the domains of the variables that cannot participate to a solution. This process is easy to visualize in a picture, even for large problems.

(There are several limitations imposed by the fact that this is a book. Films, such as those of birds in flight — as in Chapter 18 — are an obvious example. Less apparent is the fact that books can only have a limited number of illustrations; in that case the consequence is that this solution cannot be shown, but only conjured. Another, subtler, limitation is the resolution and accuracy of the printing on the page, which affects high-resolution and high-accuracy projects such as those in Chapters 11 and 16.)

Graphical and non-graphical in mathematics

Since the generation of Descartes, there have been debates in mathematics over the use of visual images. In the seventeenth century, simple algebraic equations were sometimes not considered solved unless the equations were accompanied by a picture. Thus a quadratic equation would have to be accompanied by a sketch of a conic section and a line, which showed the answer graphically. This was known as the "construction of equations."

The advent of calculus at the turn of the century also allowed scholars to easily and accurately sketch graphs of complicated functions.

The abandonment of the image

In nineteenth-century mathematics, the tendency was to mistrust images in favor of equations. Mathematicians began finding examples of pathological functions in calculus — functions that could not be drawn but were important to theoretical conjectures (for example, Weierstrass's everywhere-continuous, nowhere-differentiable function).

There were exceptions, such as John Venn's interest in logic diagrams, based on the work of Leonhard Euler, and plaster models of mathematical functions. In the last thirty years, with the advent of computers, images have come back into favor — they are used, for example, in combinatoric problems (Ramsey theory), in the topology of minimal surfaces, in knot theory, and in fractal geometry.

Images as heuristic and pedagogic tools

In the end, however, images are not used to prove theorems in mathematics. They can guide a student's understanding, help give an intuitive feel for a problem, and show off the difficulty or beauty of a proof: but they are not, in themselves, proofs.

Even this Zebra problem is not really a proof: it is a representation of a logical deduction. And yet there is more to the story, because once a mathematician becomes convinced that a graphical strategy works, then he or she may choose to work problems using pictures alone.

(And how did Dodgson solve his own puzzle? Probably with a picture — from which he could have deduced the underlying logic.)

Drawing these pictures

As you can imagine the pictures are difficult to draw using a computer graphics package. Indeed, the pictures were drawn using a little metapost program. (Metapost is a language for specifying pictures. It is closely related to Don Knuth's metafont.)

It is typical of the new interest in graphical solutions that the pictures are drawn by computer. In this case, they did not *have* to be: but in most cases, including fractal geometry, there is no alternative.

For further reading

John Venn, *Symbolic Logic* (London: MacMillan and Co., 1881); Henk Bos, *Lectures on the History of Mathematics* (Providence, Rhode Island: American Mathematical Society, 1993), chapter 2, "The Concept of Construction and the Representation of Curves in Seventeenth-century Mathematics"; for Metapost, see csweb.ucc.ie/~dongen/mpost/mpost.html.

20

Masks in Social Work

Nuala Lordan, Mary Wilson, Deirdre Quirke

The use of maskmaking as a tool in social work education offers opportunities and poses new challenges for addressing post modern dilemmas of uncertainty, chaos and crises that are everyday events in the lives of social workers and service users. Social workers in training learn to acknowledge the equality of cognitive and intuitive processes and endeavor to integrate them in an inclusive practice pedagogy. The practice of making of the mask requires the completion of a number of tasks involving the action, reflection, dialogue and action cycle and it is through this experiential learning that this practice wisdom is developed.

Choosing a partner

Following a relaxation exercise, participants choose a partner with whom to make a mask. One lies prostrate, the other kneels as they apply the materials. Trust building is a central component of the exercise.

Making the mask

It is important that the person lies down: it changes the relationship between the two. This position is a symbolic representation of the powerlessness and dependency frequently experienced by service users.

"Birthing" the mask

The "birthing" of the mask, that is when it is taken off the face, is usually an exciting and sacred event. Participants find that the experience connects with deep wellsprings of emotion. For both men and women it has frequent resonance with the life theme.

Reflections on the process

Next participants are requested to engage in a reflective exercise where they dialogue and document their reactions to the process. To translate learning from the maskmaking, questions are provided which guide the learner along the route to connect with universal themes.

Painting the mask

The penultimate stage involves participants painting their masks, which when dry are ready for the performance. Much dialogue takes place as a result of revisiting their experiences, thus furthering and deepening the process of reflection. As a result new knowledge of self and the other begin to emerge.

Dialogue and evaluation

The finale involves presenting of each participant's mask to the other using the medium of performance. Participants dress the mask for presentation using colorful materials. This is followed by a performance or a play of the mask that is made, using mime, song, dance or words. This culminates with the presentation of the mask to each other. Symbolically and figuratively this actualizes the concepts of giving and receiving.

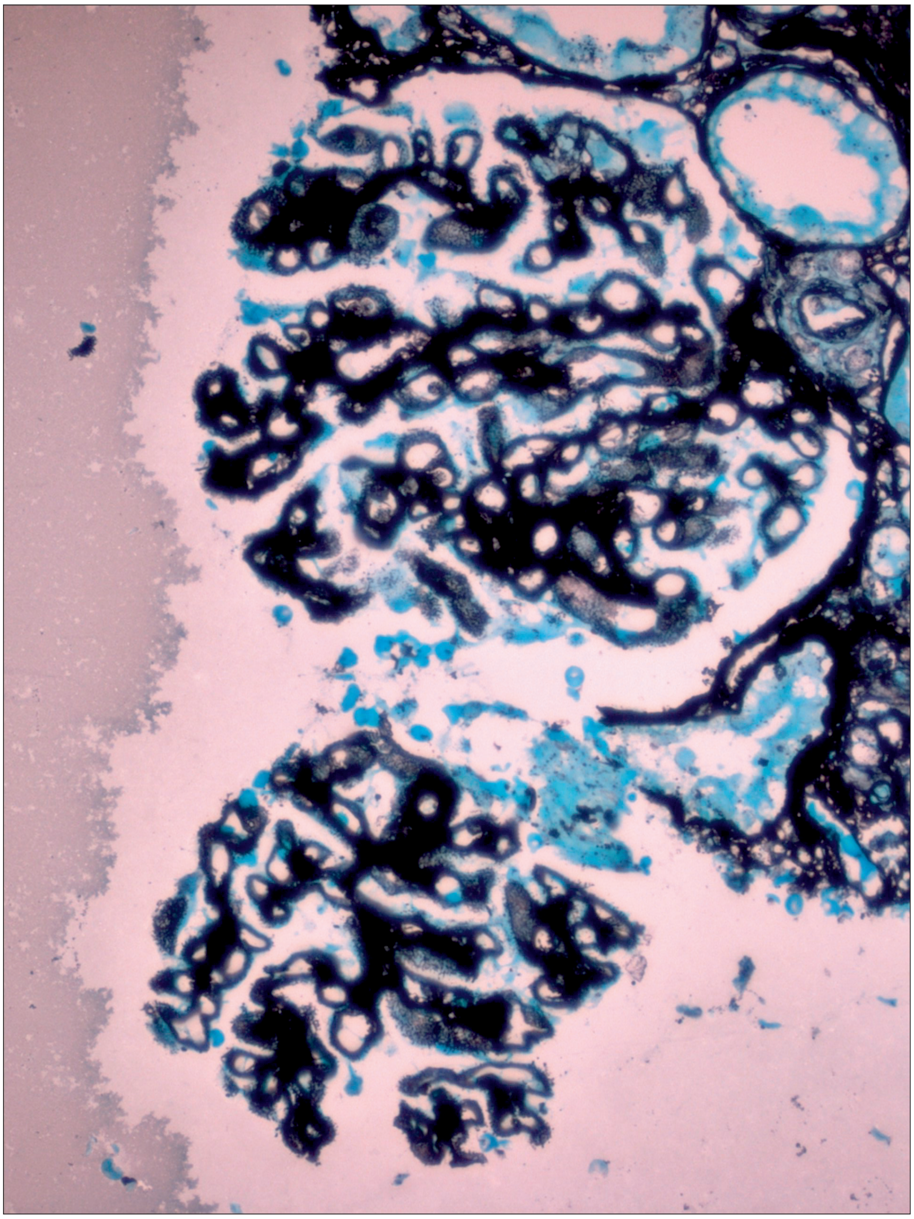
Ends of the exercise

The maskmaking experience provides students with an opportunity to explore the process of giving and receiving within the context of social groupwork and to develop greater awareness of self and other.

The process is limited by the voluntary nature of participation. Maskmaking cannot be a compulsory or core teaching unit, because the students are exposed to the risk of encountering both the familiar and the strange within themselves and the other. Participants get different things from the experience, depending on their levels of self-awareness and commitment to the process.

For further reading

P. Freire, *The Pedagogy of the Oppressed* (New York: Herder and Herder, 1970); D. Kolb, *Experiential Learning* (Englewood Cliffs, NJ: Prentice Hall, 1984); N. Lordan, M. Wilson, and D. Quirke, "Breaking the mould: Maskmaking as an 'inclusive' Educational Tool," in *Life's Rich Pattern: Cultural Diversity and the Education of Adults,* edited by J. Jones and G. Normie. Papers from the 7th International Conference on Adult Education and the Arts, Glasgow, Scotland, July 2002; O. Luedemann, "Interacting Productively with the Familiar and the Strange", in *Fromm Forum* (Heidelberg: International Fromm Society, 2003).



21

Diagnosis of Membranous Glomerulopathy by Kidney Biopsy

Nollaig Parfrey

Nephrotic syndrome develops when damage to the kidneys leads to loss of protein in the urine. It is associated with diabetes, but has many other causes. The commonest cause of nephrotic syndrome in adults is membranous glomerulopathy.

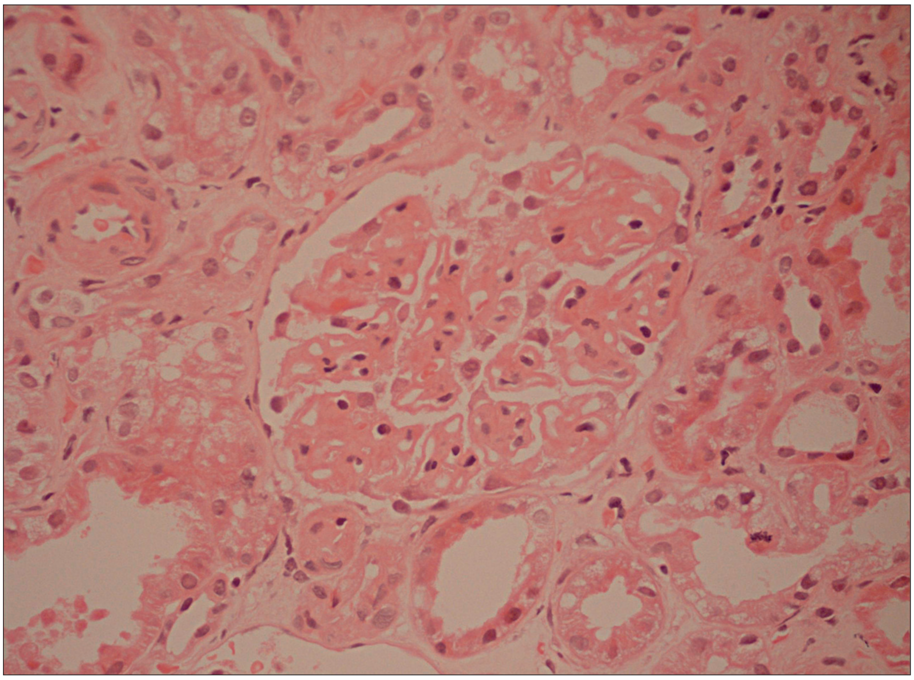
The diagnosis of membranous glomerulopathy is not straightforward and is not made based on a single feature. It is complex, and utilises the complementary techniques of light microscopy, fluorescence microscopy and electron microscopy. A definite diagnosis requires a biopsy of the kidney.

The anatomy

To read the images, it is necessary to briefly review the relevant anatomy.

Glomeruli selectively filter waste from the blood and produce urine which is then sent to the bladder. They are round structures scattered throughout the kidneys. They are largely made up of small blood vessels named capillary loops. A capillary loop consists of a blood vessel lined by endothelial cells which lie on a basement membrane; the basement membrane is lined on its other side by epithelial cells. Thus, the basement membrane is the meat in the sandwich between endothelial cells and epithelial cells.

Membranous glomerulopathy is an autoimmune disease linked to susceptibility genes and caused by autoantibodies to an autoantigen in the kidneys. This leads to formation of immune deposits in the glomerular basement membrane under the epithelial cells. The basement membrane grows up around the immune deposits.



Haematoxylin and eosin

Haematoxylin and eosin (H&E) is a common stain in light microscopy (photo above). The haematoxylin is a base, and stains things blue; eosin, the "counter-stain," is acidic, and stains things red. Effectively, it makes a colorful "picture" out of otherwise translucent tissues. Here H&E staining reveals diffuse thickening of capillary loops in the glomerulus. The capillary loops appear thickened because the basement membrane is thickened.

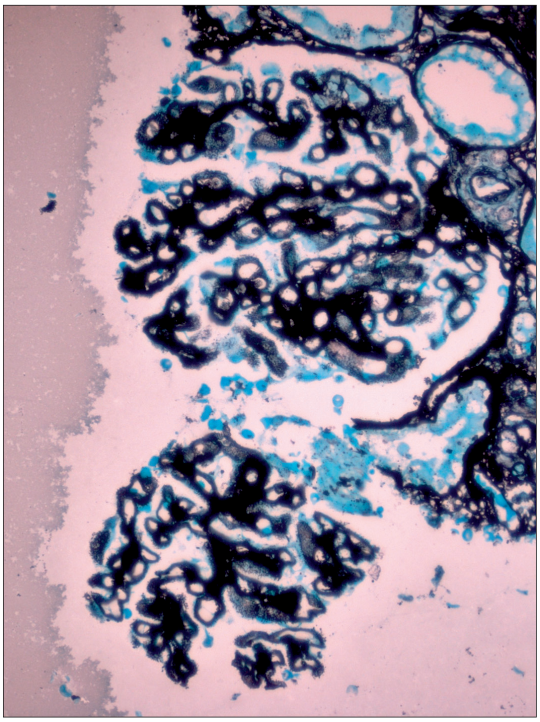
Silver staining

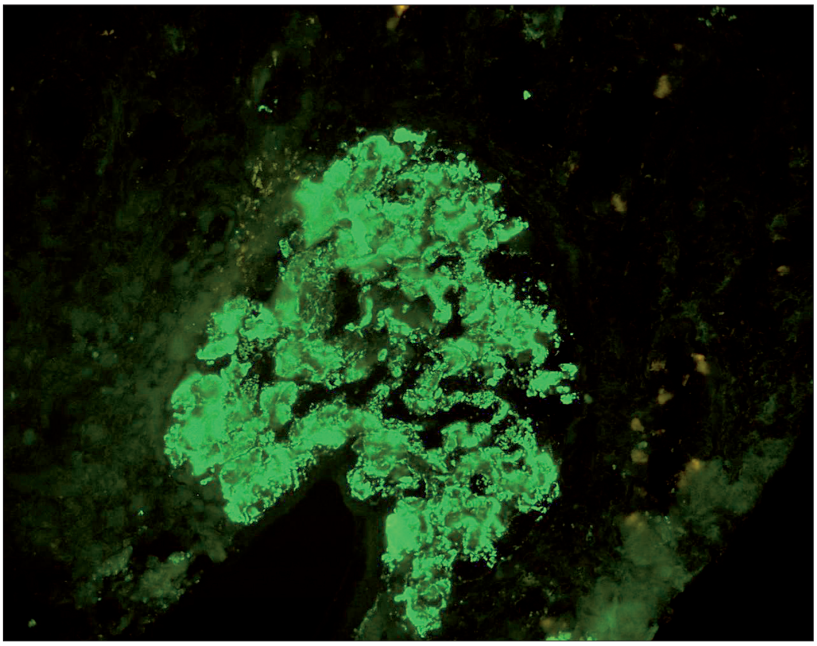
Silver staining is another common technique in light microscopy (see the top image on the next page).

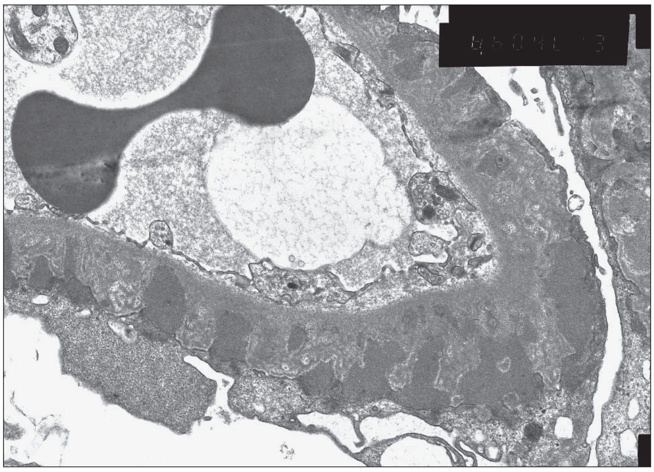
Here a silver stain of a glomerulus shows multiple little spikes of silver-positive black material. The silver spikes are not the immune deposits but rather spikes of basement membrane that grow around the immune deposits.

Immunofluorescence

Immunofluorescence microscopy is a more sophisticated technique in light microscopy (see the bottom image on the next page). Fluorescent dyes are attached by antigen-antibody binding to molecules of interest present in the tissue.







In this case, this immunofluorescence image of a single glomerulus shows strong diffuse positive green immunostaining using a fluorescein-labelled antibody directed against immunoglobulin G; it reveals immunoglobulin G deposits in a peripheral capillary loop pattern.

Electron microscopy

Transmission electron microscopy (photo above) is used for very high magnification at the cellular and subcellular level to examine features that are not visible at the light microscopic level. Here multiple electron-dense immune deposits (black) are seen in the basement membrane under the epithelial cells.

Conclusions

In this case, we see diffuse thickening of capillary loops, silver spikes, and immunoglobulin G deposition; these immune deposits are shown to be subepithelial. The combination of clinical findings (protein in the urine and reduced protein in the blood) and light, immunofluorescence, and electron microscopic findings establish the diagnosis of membranous glomerulopathy.

No one of these techniques is sufficient in itself, and each one requires extensive experience to develop confidence in dealing with subtle changes. The diagnosis is therefore a combination of multiple imaging technologies and visual skills that are obtained slowly from experience of many cases. Few images yield relatively straightforward visual criteria (such as the spikes in the silver stained sample); most require qualitative assessments and extensive comparisons of similar cases. In that sense, the material presented here is necessarily a less adequate representation of its subject than most other chapters in this book.

For further reading

Renal Pathology with Clinical and Functional Correlations, second edition, edited by C.G. Tisher and B.M. Brenner (Philadelphia: Lippincott, Williams, and Wilkins,1994); *Heptinstall's Pathology of the Kidney,* fifth edition, J.C. Jennette et al. (Philadelphia: Lippincott-Raven, 1998); *Robbins and Cotran Pathologic Basis of Disease*, seventh edition, edited by V. Kumar, A.K. Abbas, and N. Fausto (Philadelphia: Elsevier Saunders, 2005).

22

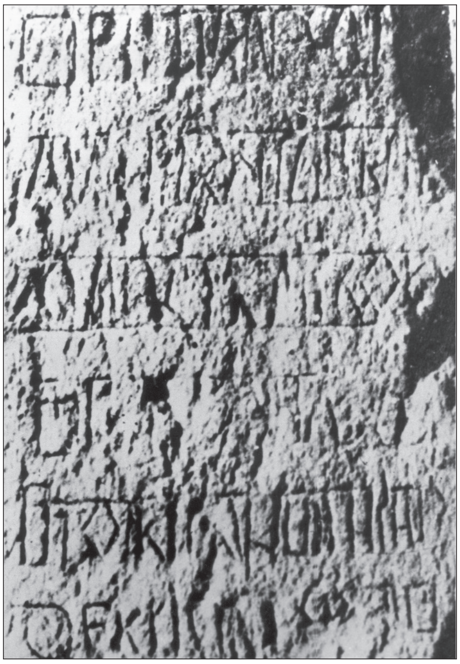
A Virtual Archive of Inscribed Stones

Orla Murphy, Elisabeth Okasha, Thierry Daubos, and Dáibhí Ó Cróinín

Here a team uses a laser scanner to capture the surface of an inscribed stone in the field at Toureen Peacaun, Ireland, Co. Tipperary. The scanner collects a *point cloud,* a set of points at known *x, y, z* locations in space. The resulting digital file is comprised of voxels (3-D pixels) in the computer. It can be used to machine three-dimensional replicas for study and exhibition; and it is also useful for checking contentious interpretations, or — most generally — for preserve monuments for the future. As a "point cloud," the stone can easily be disseminated on the internet.

The object

In this case, the team began with a positive cast of an inscription on a high cross shaft at Toureen Peacaun. The cast is shown at right; an old photograph of the actual monument is reproduced toward the end of this essay.



The 3-D scan

This is the same object, in the 3-D model. The blue colour is just one of the default textures available in the software (called Rapidform) to visualize the model using shaded rendering.

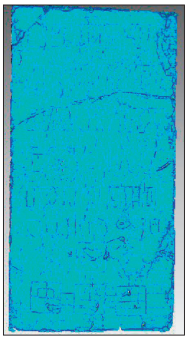
What seems to be a continuous blue surface — it would be pixels in a digital image, or particles of dye in a photograph — is a set of linked points in space. In this model the inscribed area is 37.4 cm x 73.4 cm height, and it is actually comprised of linked points in space, like a Buckminster Fuller lattice. This one has 411,000 vertices and 821,000 triangles.

The nominal resolution is 1mm, but in practice, because of the need to collate "point clouds" of voxels from individual scans, and to filter the results, the effective resolution is 1.3 mm.

The inscription captured in the computer

Now the image is under the operator's control. It is possible to adjust the ambient, diffuse and specular colours of the material, as well as a shininess parameter, in order to enhance the reading of the characters of the inscription.

The 3-D file can also be lit from various directions. Its surface texture can be changed and its relief can even be exaggerated.



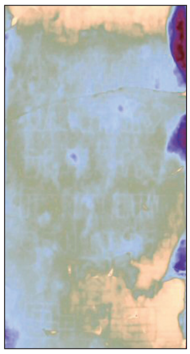
Minimum curvature texturing

This picture shows one of the possibilities, called minimum curvature texturing. Here the computer searches for the flattest curve that will pass through a given point on the surface. If the point is at the bottom of a depression — like a carved letter — then it has a negative value. The computer collates numbers for each point.

Then, to make the numbers visible, the negative values can be assigned a darker blue. So this is not at all like a normal photograph: it is a mapping of numerical values that record curvature.

Flattening the stone's surface

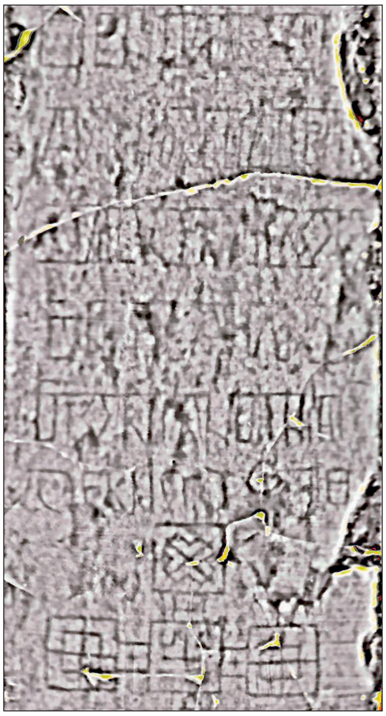
The natural fluctuations in the surface of the stone are then removed using IDL, Image Data Language. The idea is to substract the background height fluctuations whose frequencies are below the frequency of the inscription in order to make it appear as if it had been written on a flat surface.



This is the original 3-D model, imported into IDL and shown as a "height field" — like a topographic map. The 'haze' colour table in IDL makes the highest parts gold and the lowest purple.

There is a low-frequency variation in height across the model (a shallow dip, top to bottom, like a valley) that impedes a clear reading of the inscription. In order to remove it the image is processed using "wavelet filtering,"; a result is shown in the photo below.

Movies from single photographs

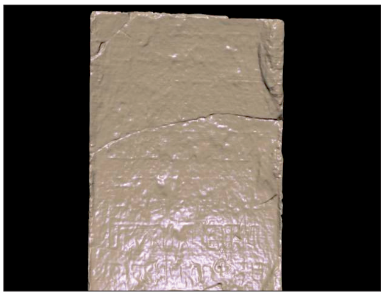


It is also possible to make movies from the 3-D model. At the bottom of the page is a still image from a synthetic video sequence generated by importing the 3D model into the 3D Studio Max software. An artificial texture with high reflectance properties is applied to the model and different light conditions were simulated by moving a projector in circle around the model. (The only other technology that allows films to be made from single photos is holography.)

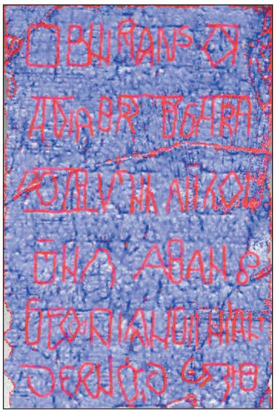
What does the inscription say?

The 3-D file (for example at left) compares favorably with an old photograph (next page).

Even so, the inscription on the monument is almost completely illegible, because lichen and water damage obscure it. Reading is also problematic because of the possibility that the inscriber used a "deluxe" uncial script. This is most clear in lines 2 and 5 (see the diagram on page 219). Examples similar to the script used in the highly decorated gospel incipits in both the Book of Lindisfarne and the Book of Kells (see Chapter 15) suggest that the inscription would be difficult to decipher even if it was completely legible.



The layout on the stone also makes interpretation difficult. The carver set out parallel lines as a boundary or marker for the lettering and at times it is difficult to decipher when a letter begins and where the ruled line ends. A clear example of this is the lozenge shaped O. In the text given below, it is therefore sometimes shown as bracketed, and sometimes not, reflecting this difficulty.



Line 1	OP … M..A..O I
Line 2	AV …X I O Z I …III
Line 3	..O…………………OOI
Line 4	D..I……………………..
Line 5	BIOIRII..AINOIM LAI
Line 6	Dern(ad) O(ε)G I D

Here letters within parentheses indicate a possible reading and ellipses (…) indicate illegible parts of the inscription.

Scanning the world's sculpture

Scans of sculpture have been initiated in several countries. The National Technical University in Athens has scanned a model of Praxiteles's *Hermes* at a theoretical resolution of 0.17mm. In 1998, Stanford University launched the "Digital Michelangelo" project, which digitized Michelangelo's *David* at a theoretical resolution of 0.27mm. (In fact, the model is at 1mm resolution, partly because of the large dataset; the theoretical resolution is limited by the marble Michelangelo used, which is slightly translucent and grainy.)

Is a sculpture or a monument well enough preserved at 1mm resolution? Certainly that is finer than any verbal description, and finer than anything required by historical and critical analyses.

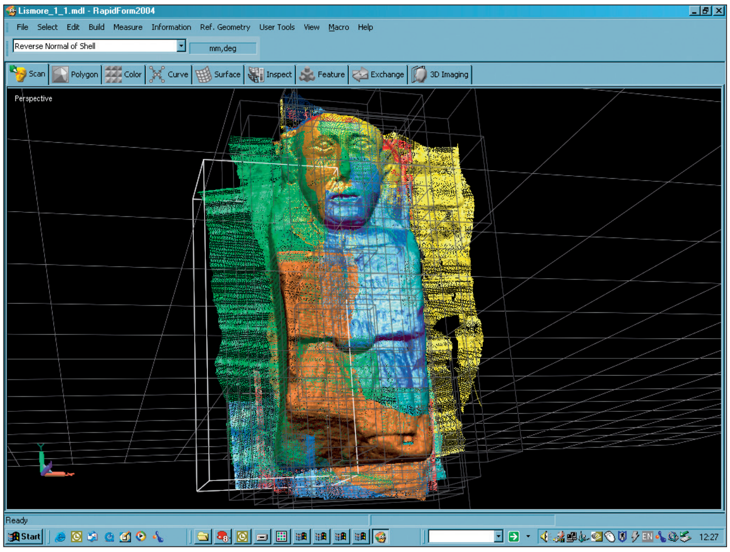
The copy becomes the original

The 3-D digital archives that are being built up are unprecedented in art history and archeologg. For the first time, the copy not only replaces but surpasses the original object: and it does so by being digital rather than analog — by consisting of discrete data points rather than a continuum of marble, stone, or plaster. Eventually, with degradation or loss of the original, the 3-D scan might become the new original.

Allegories of reading

The Irish project has also uncovered a lovely example of reading that is not quite reading. In Lismore Cathedral, in County Waterford, Ireland, there is a relief sculpture showing a man with an open book. The book is illegible, but when it is laser scanned, letters appear.

And yet… it isn't quite legible. The figure is in the style known as Hiberno-Romanesque, from 1150-1190, but the book he was meant to show us cannot quite be read. Like many of the scans made by the inscribed stones project, it results in a dramatic increase in visibility that does not quite lead to an increase in legibility. Sometimes visual images are rich with *apparent* meaning, and still poor in articulable meaning.


Lismore_1_1.mdl - RapidForm2004
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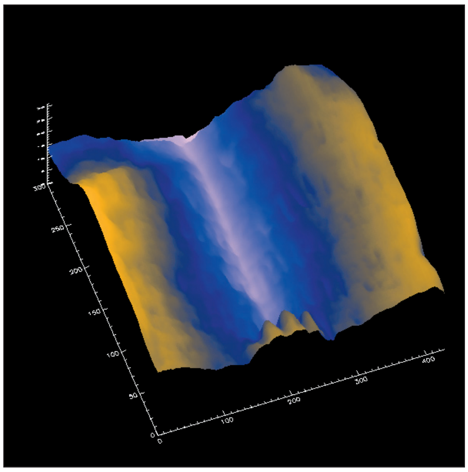
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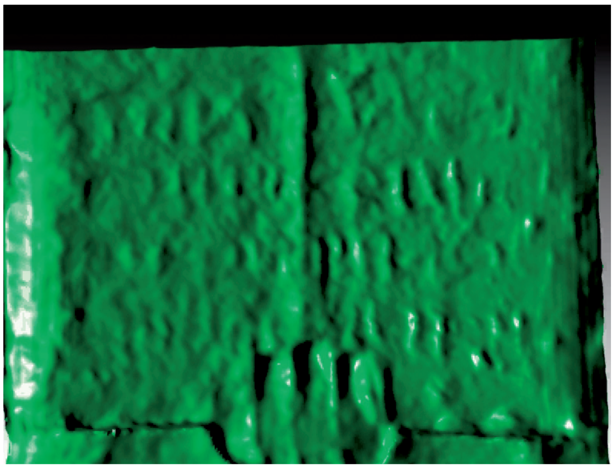
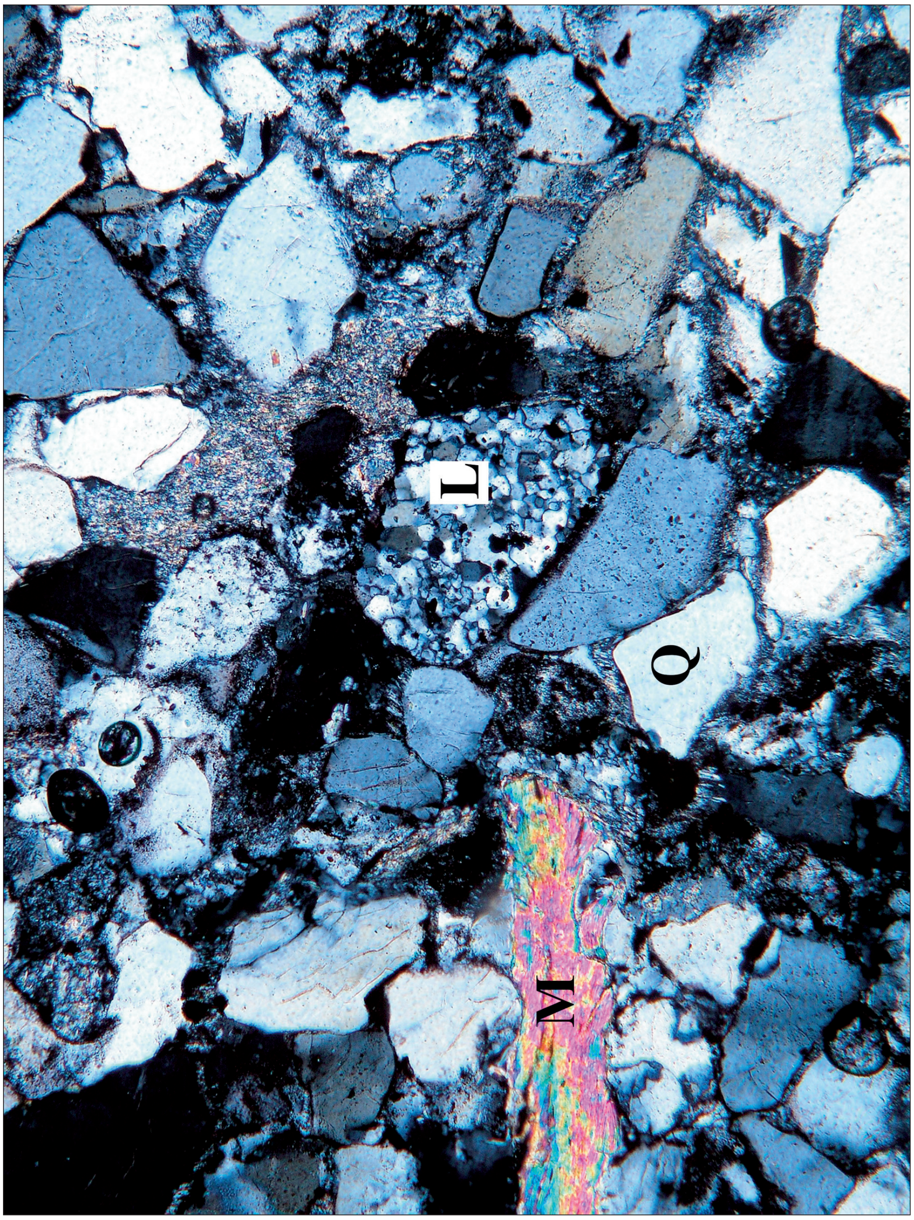


For further reading

An essay "Laser Profilometry of Medieval Inscribed Stones," including the stone described here, is at: www.foundationsirishculture.ie/main.php?id=4; and see also graphics.lcs.mit.edu/~dorsey/papers/stone/. For more on scanning stones, see: Julie Dorsey, Alan Edelman, et al., "Modelling and Rendering of Weathered Stone," *Computer Graphics* (Proceedings Annual Conference 1999, ACM SIGGRAPH) 3 (2004); and Alistair Carty, "Digital Recording of Pictish Sculpture," *Archaeoptics* 4 (2004), at www.archaeoptics.co.uk. Technical information is given in Maria Tsakiri, Charalambos Ioannidis, and Alistair Carty, "Laser Scanning Issues for the Geometrical Recording of a Complex Statue," www.archaeoptics.co.uk. For other cases, see "The Stonehenge Lasershow," *British Archaeology* 73 (November 2003); www.britarch.ac.uk/ba/ba73/feat1.shtml; www.stonehengelaserscan.org; and For the Digital Michelangelo Project see graphics.stanford.edu/data/mich/.


L
Q
M

23

Deformation of Grains in Sandstone Rock

Pat Meere and Kieran Mulchrone

Microscopic grains in sandstones are slowly deformed by tectonic forces within the rock. A study by Pat Meere, a geologist, Kieran Mulchrone, a mathematician, and Kingshuk Roy Choudhury, a statistician, uses a combination of grain measurements from actual rocks along with mathematical models of how ideal grains deform, in order to statistically quantify the amount of strain associated with the deformation event. (Strain includes translation, distortion, rotation, and dilation — all the things that can happen to grains in rocks.)

The thin sections

They begin with samples of a continental and marine sandstone, cut in thin sections and observed under a polarizing microscope. The view in the opening photo is 2 mm across.

(The colors in one part of the photo are produced by the polarizing microscope; such colors contain information about the crystal orientations of the grains.)

An undeformed sample

The photo shows what is known as a *low strain regime:* that is, the grains are not strongly deformed. This image shows quartz grains (Q), in random orientations. Also present is a grain of siltstone (L), and large piece of mica (M), which shows the polarisation colours.

A deformed sample.

In the sample shown at the top of page 227, the grains have been deformed by pressure; the grains are clearly both distorted and aligned. The object of this experiment is to model such changes.

Outlining grains

Using customized image-analysis software developed by Kingshuk Roy Choudhury, Meere and Mulchrone defined the boundaries of selected quartz grains, called *clasts*. (Notice the red outlines in the photo on the lower-left on the next page).

It would be possible to define these outlines manually, but automated methods are preferable because they make use of multiple images, each made with a different orientation of polarized light, resulting in interpolated outlines that are more accurate than outlines drawn by hand.

The shape factor

Each grain has a *shape factor,* which is determined by matching it to an ellipse (see the top illustration on page 228). This is similar to the determination of the shape factor discussed in Chapter 3. What matters here is the *aspect ratio* of each ellipse (the ratio of its long and short axes) and its *orientation* — those data are then used to estimate strain.

The mathematical model

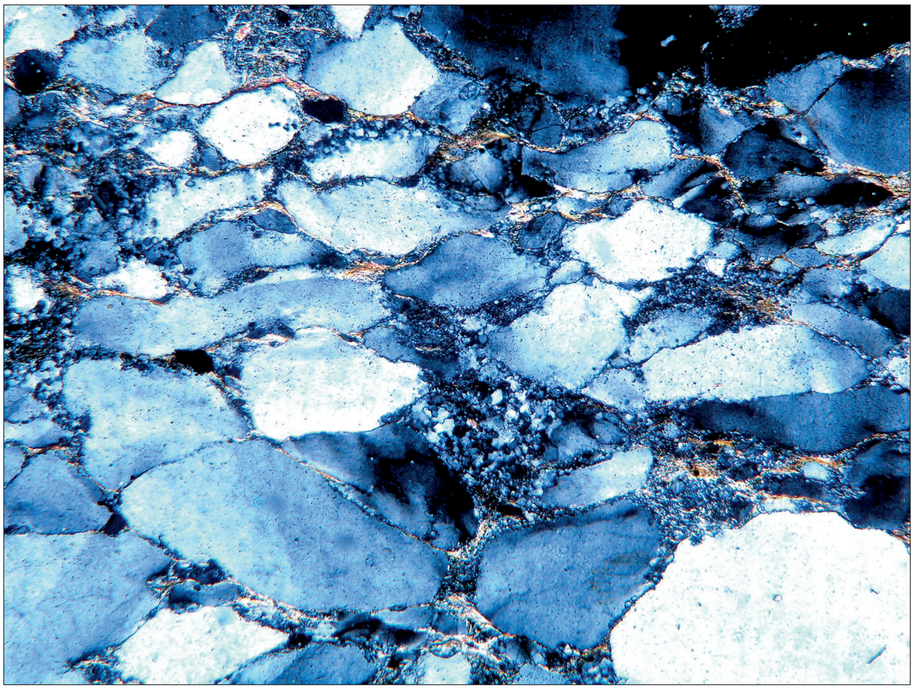
Next comes the mathematical modeling of the deformations that are observed in the samples. Mulchrone uses the physics of fluids to derive equations describing the deformation of individual grains. In this model grains can be more or less viscous than the surrounding material (i.e. harder or softer). In two dimensions a grain (with long axis *a* and short axis *b*, whose long axis makes an angle $\varnothing$ with the *x*-axis) changes shape and orientation according to the following equations:

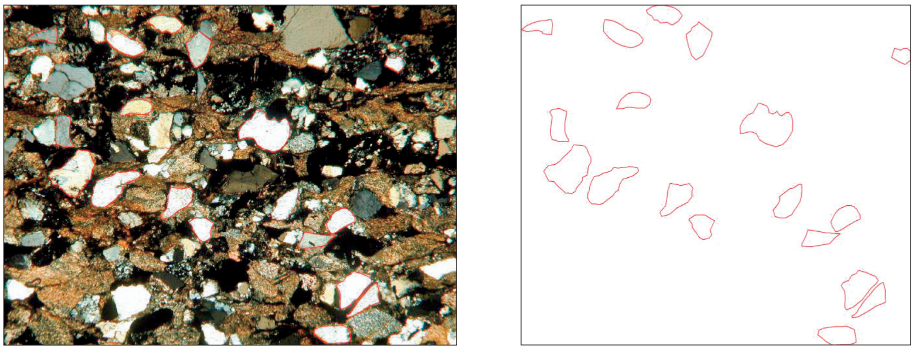
$$\frac{d\varnothing}{dt} = ?\,(L_{21} - L_{12}) +$$

$$\frac{(a+b)\,(a^2+b^2+2\mathrm{ab}\,(\mu_r-1))\,((L_{12}+L_{21})\cos 2\varnothing - 2L_{11}\sin 2\varnothing)}{2\,(a-b)\,(a^2+b^2+2ab\mu_r)}$$

$$\frac{da}{dt} = \frac{a\,(a+b)^2\,\mu_r\,(2L_{11}\cos 2\varnothing + (L_{12}+L_{21})\sin 2\varnothing}{2((a^2+b^2)\,\mu_r + 2ab)}$$

$$\frac{db}{dt} = \frac{a\,(a+b)^2\,\mu_r\,(2L_{11}\cos 2\varnothing + (L_{12}+L_{21})\sin 2\varnothing}{2((a^2+b^2)\,\mu_r + 2ab)}$$

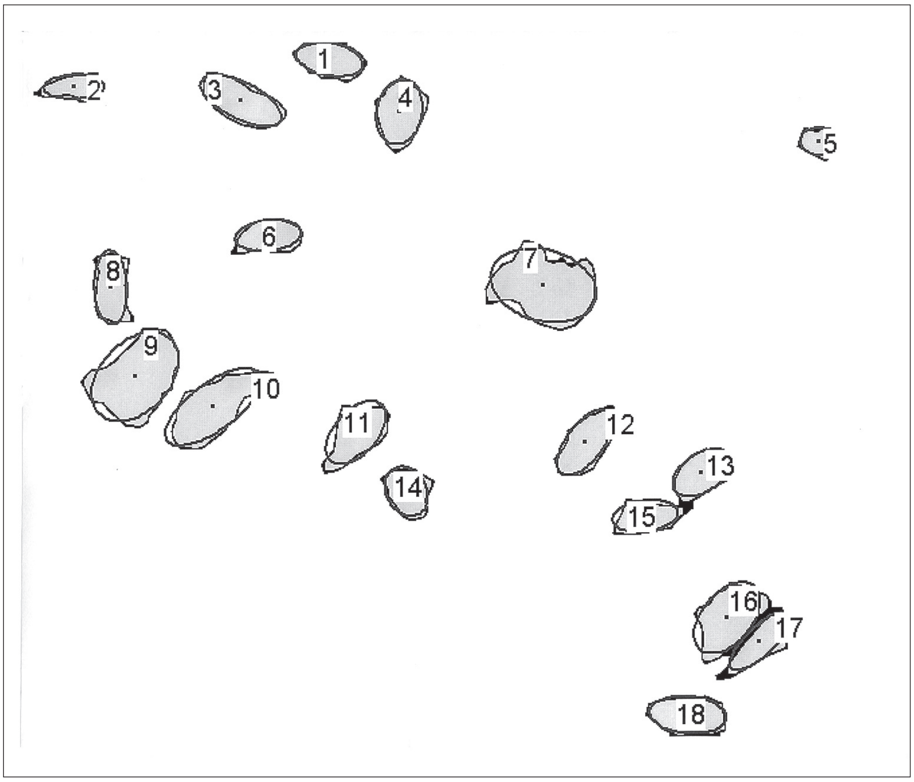




where all the L's describe the external flow and μ_r is the ratio of the external to the internal viscosities. These equations are highly non-linear and reflect the complexity of the motions.

Mathematical graphics

The bottom illustration on the next page is a screen snapshot from animation software developed to visualize the mathematical model. In the top-left frame, a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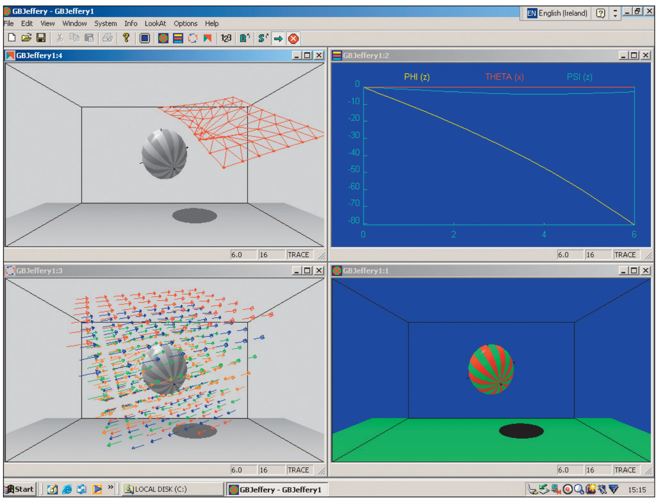


triangular grid of points displays how the surrounding material deforms due to the motion of a nearby grain, which is modelled as a rigid ellipsoid.

In the bottom-left frame the arrows show the velocity of surrounding material near a rigid ellipsoid. The top-right frame gives a conventional 2D graph of the variation of ellipsoid angles against time; and the bottom-right image gives an uncluttered view of the ellipsoid as it moves with time.

Combining observation and calculation

The project involves both observation and calculation: observation of large numbers of grains in thin sections, and mathematical models of grains. The results can be compared statistically.

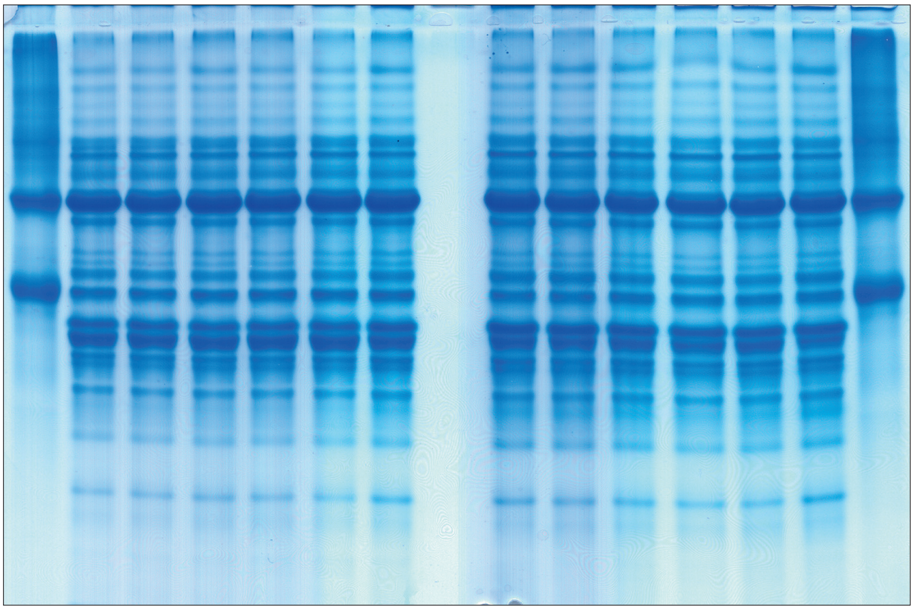
As with all scientific work, it is necessary to continuously question the methods and assumptions; the research is ongoing. Meere and Mulchrone hope to improve their methodological approach and gain a better understanding of the physics involved in grain deformation, thereby enabling the construction of more realistic mathematical models.

The place of images

Note, then, the very complex role images play: they provide the raw data, but they are analyzed by an automated image-analysis routine. Images serve as helpful aids in Mulchrone's mathematical modeling, but the end result in both Meere's analyses and Mulchrone's models is mathematical data, which are then compared statistically — that is, independently of vision.

For further reading

Pat Meere and Kieran Mulchrone, "The Effect of Sample Size On Geological Strain Estimation From Passively Deformed Clastic Sedimentary Rocks," *Journal of Structural Geology* 25 (2003): 1587-95; Kieran Mulchrone, F. O'Sullivan, and Pat Meere, "Finite Strain Estimation Using The Mean Radial Length of Elliptical Objects With Bootstrap Confidence Intervals," *Journal of Structural Geology* 25 (2003): 529-39; Kieran Mulchrone and K. Roy Choudhury, "Fitting An Ellipse To An Arbitrary Shape: Implications For Strain Analysis," *Journal of Structural Geology* 26 (2004): 143-53.



24

Gel Electrophoresis of Cheddar Cheese

Paul McSweeney

These pictures are from a study of the caseins in Cheddar cheese; casein is the principal protein of milk, and the structural matrix of cheese.

Most cheese varieties are ripened for periods ranging from about two weeks to two or more years. During ripening, microbiological and biochemical changes occur which result in the development of the flavour and texture characteristic of the variety.

Electrophoresis is a technique used in biochemistry and food science to separate and identify proteins. (The image itself is called an electrophoretogram.) In the opening photo, the column on the left is casein. The next six lanes are six samples of cheese, each two months old. Then come six lanes of cheeses that are six months old, and finally another reference lane of casein. It's apparent that the caseins change during the aging of the cheese, fragmenting into separate chemicals.

The process

Droplets of cheese (dissolved in a buffer) are placed at the top of the gel, and an electric field is applied. In the photos on the next two pages, the gel is attached to the source of electric current.

Depending on the pH of their environment, proteins may be positively or negatively charged. Thus, they can move in an electric field and are attracted down the lane towards the oppositely charged electrode. The proteins are differently charged, and move at different rates; each short horizontal band is therefore one type of protein — either one of the caseins or one of the products produced from them by the action of the enzymes chymosin (used to coagulate the milk) or plasmin (a chemical naturally present in milk).

After the proteins have been given a chance to move along the channels, the electricity is turned off, and a dye is used to reveal them. (Otherwise they would be invisible.)

Visual analysis

This gel shows electrophoretograms of whole casein, distinguished into α_s1- and β-casein (see the diagram on page 235). They are degraded during ripening. In the two month-old Cheddar cheese samples, β-casein has been degraded slightly by the action of plasmin, an enzyme indigenous to milk, to form three peptides.

The α_s1-Casein has been degraded almost completely to two peptides, α_s1-CN and α_s1-CN. The agent that effected the degrading is chymosin, the enzyme in rennet used to coagulate the milk.

The numbers in parentheses denote the fragments of the protein cut off by the enzyme. Thus "f29-209" is a portion of β-casein. The whole molecule of β-casein is 209 amino acids long; "f29-209" is a fragment cut along the peptide bond between amino acids at positions 28 and 29.

The uselessness of the visual evidence

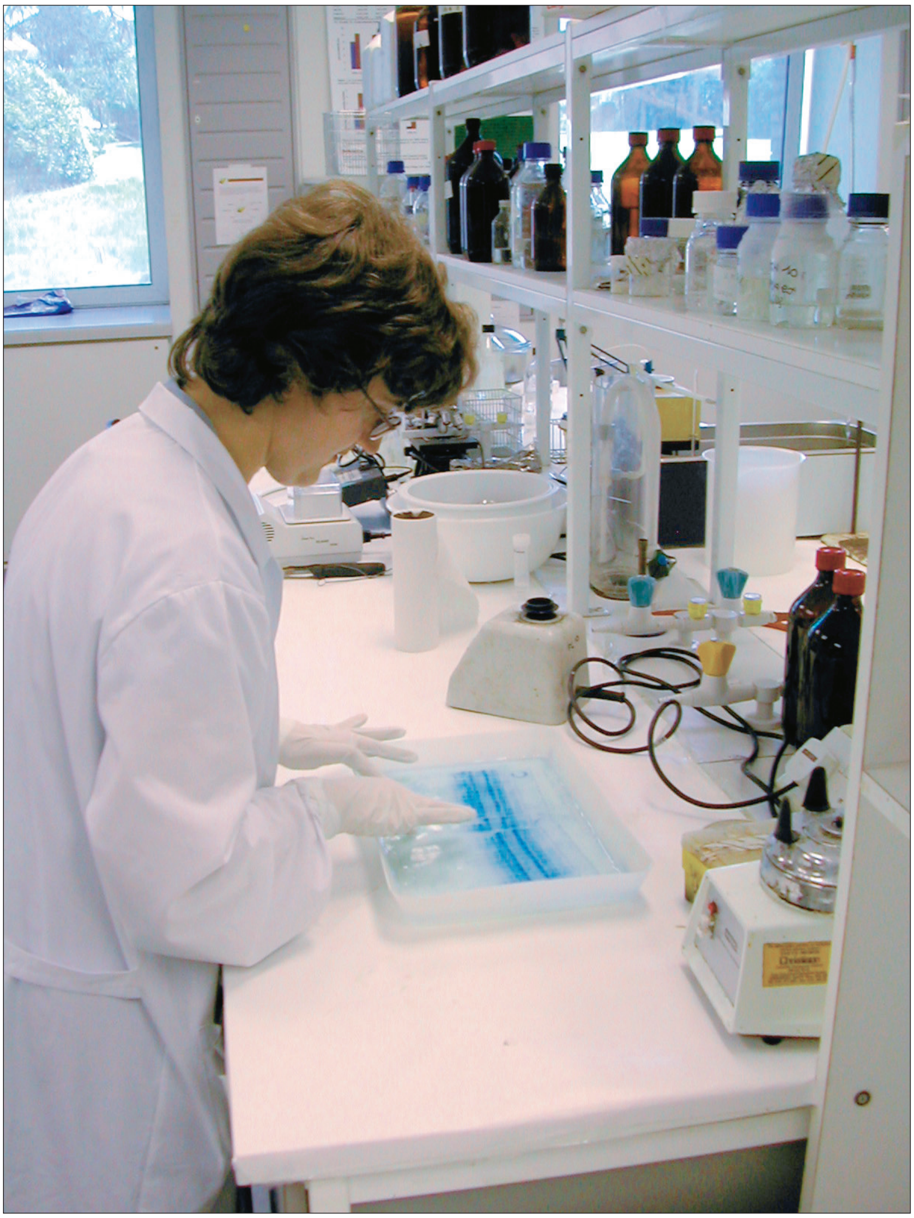
What can be seen on the original photo? A trained eye would see right away that the intensities of certain bands on the left half aren't the same as the intensites of

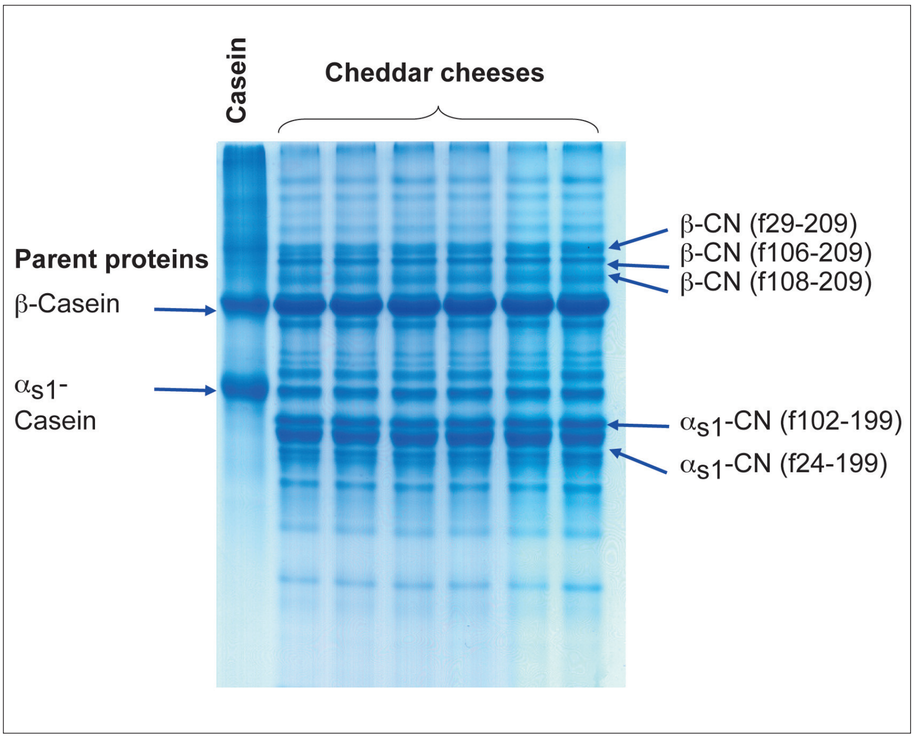
bands on the right half. For example compare the bands labelled α_s1-CN (f102-199): they are denser on the right, in the cheeses that have been aged longer — indicating more of the casein has been degraded into that particular fragment. Clearly, however, it is not easy to make these distinctions by eye, and normally researchers do not use images like the first one, or even like the one that has been labelled.

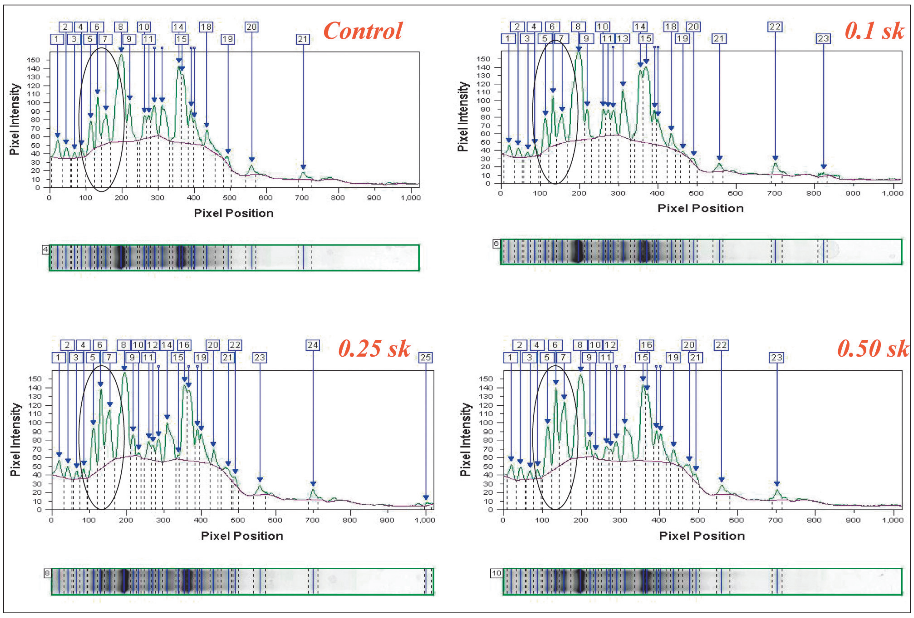
Statistical analysis

Instead the electrophoretograms are recorded by scanning the gel, and the amounts of each protein are quantified by densitometry. In the picture below, from another study, the lanes are placed horizontally underneath scans which quantify the density of each protein band.

Data like this can then be analysed statistically, across a number of samples, by multivariate analysis. Visual evidence is not important. Despite the lovely blue-and-white picture, what is available to the eye is only a way-station to quantifiable information. This result is disappointing for an analysis bent on




Casein
Cheddar cheeses
Parent proteins
β-Casein
α_{s1}-Casein
β-CN (f29-209)
β-CN (f106-209)
β-CN (f108-209)
α_{s1}-CN (f102-199)
α_{s1}-CN (f24-199)


Control
0.1 sk
0.25 sk
0.50 sk
Pixel Intensity
Pixel Position

visualization, but it is broadly typical of the sciences, where the visual is likely to be a starting point that can sooner or later be discarded.

For further reading:

McSweeney, "Biochemistry of Cheese Ripening: Introduction and Overview," in *Cheese: Chemistry, Physics and Microbiology*, vol. 1, *General Aspects*, 3rd edition, edited by P.F. Fox, P.L.H. McSweeney, T.M. Cogan and T.P. Guinee (London: Elsevier, 2004); Upadhyay, V.K., P.L.H. McSweeney, A.A.A. Magboul and P.F. Fox, "Proteolysis in Cheese During Ripening," in ibid; and McSweeney, "Biochemistry of Cheese Ripening," *International Journal of Dairy Technology* 57 no. 2/3 (2004): 127-44.


IFAW

25

Europhlukes

Emer Rogan and Simon Ingram

In Günther Grass's novel *Dog Years,* there is a boy whose eyes are so sharp he can tell every blackbird in a flock. Ornithologists might love to have that ability. Primatologists like Jane Goodall develop the ability to tell every individual in a group of apes or monkeys. But in general, naturalists have to be content with counting bodies, and they are often unsure exactly which individual is which.

Europhlukes is an attempt to remedy that for the study of dolphins and whales. The project begins with a database of photographs of the fins of whales and dolphins. Typically the fins have scars and scratches — bites from predators, or just the wear and tear of normal life. Those marks serve as fingerprints.

Examples

Five examples are given here. In bottlenose dolphins the most useful identifying feature is the dorsal fin; in sperm whales the trailing edge of the tail flukes are the most uniquely marked feature.

Long-term study

By repeatedly photographing and identifying uniquely marked individuals scientists can follow these animals between years and between geographic areas. In this way it is possible to examine an individual's ranging patterns, its social behaviour and other aspects of its ecology.

Automated recognition of individuals

Just as in the police software that identifies people from surveillance cameras, Europhlukes is developing the capacity to instantly identify individual whales and dolphins.

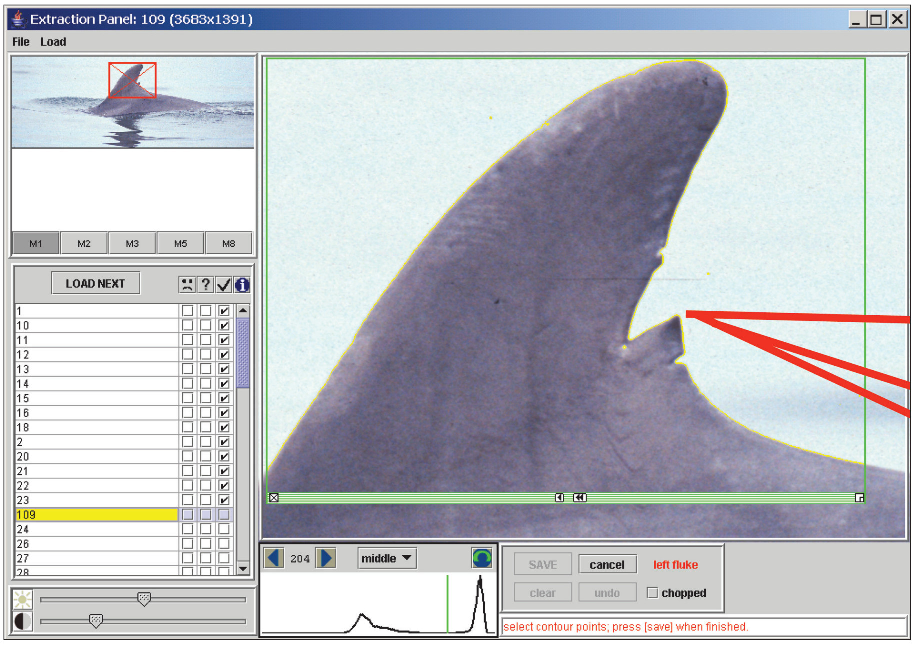
Europhlukes is EU funded, and is coordinating whale and dolphin researchers working throughout Atlantic Europe. The project is establishing a shared on-line data base of photos and related data to assist in the data storage and matching process.

Computer identification

In the two screenshots, the yellow line created by the computer shows the unique edge shapes of whales' tails and dolphins' dorsal fins.

The future of computer-assisted identification

Computers analyzing CCTV camera feeds can already identify people in crowds. (The crucial parameter in those identifications is the distance between the eyes.


Extraction Panel: 109 (3683x1391)
File Load
M1 M2 M3 M5 M8
LOAD NEXT
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middle
SAVE
cancel
left fluke
clear
undo
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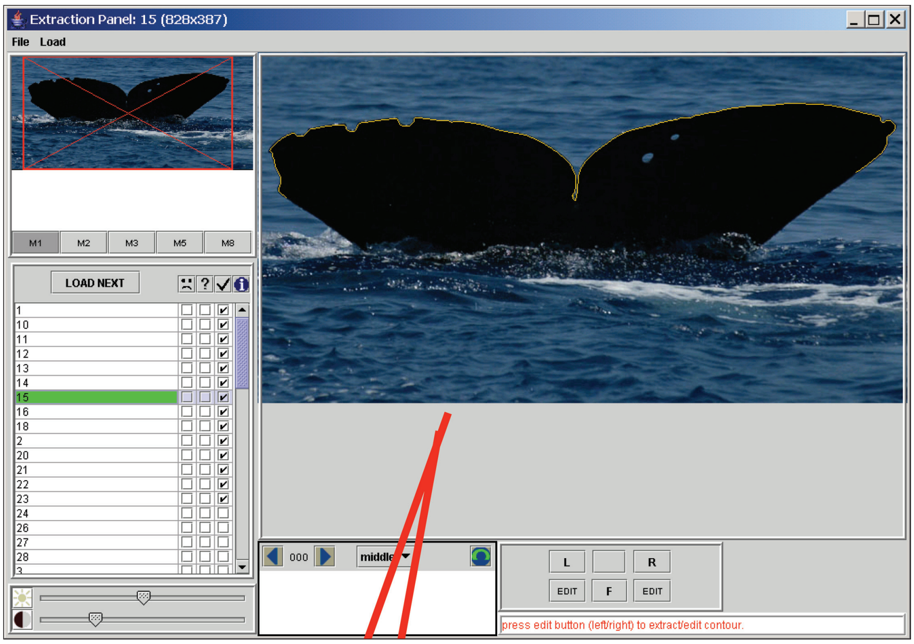
select contour points; press [save] when finished.


Extraction Panel: 15 (828x387)
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press edit button (left/right) to extract/edit contour.

Wrap-around dark glasses can help foil the cameras.) Anonymity in crowds is, in theory, a thing of the past.

With projects like Europhlukes, it may be only a matter of time before all animals are individuals — and there are no more flocks, or pods, or herds, but only individual animals with numbers (or names).

For further reading

Visit http://europhlukes.maris2.nl/.


Röntgenaufnahme von JOHN HEARTFIELD
ADOLF, DER ÜBERMENSCH: Schluckt Gold und redet Blech
675

26

Sabine Kriebel

Using Photography as a Weapon

Most images in this book have no immediately apparent political meaning. By comparison, many images studied in the history of art have overt religious, ethical, and political significance.

The related field of visual studies is concerned with images in mass communication — many of which have political purposes. From a visual-studies standpoint, *all* the images in this book have their politics, even if it goes unremarked.

Visual studies sets out to use images — *any* images — as occasions to educate students as reflective members of society. Visual studies is therefore opportunistic: it can take images from any field and read them with an eye to the political work they do.

This chapter gives a brief sample of the analysis of the politics of images.

John Heartfield

John Heartfield was the pseudonym adopted by the German artist Helmut Herzfelde to protest German chauvinism and anti-British sentiment during World War I; he openly took sides with the enemy during period of virulent nationalism.

Anglicizing his name signaled Heartfield's internationalist convictions, as much as it declared his Dadaist predilections. His involvement with Berlin Dada was a leftist, anti-militarist, anti-bourgeois protest in which he developed the medium of photomontage as an anarchist weapon. During the 1920s and 1930s, he became the image-maker of the German Communist Left, producing a copious supply of mass-reproduced posters, book jackets, and satirical photomontages. Most significantly, he made 237 photomontages for the popular left-wing *Arbeiter Illustrierte Zeitung* (*AIZ*), or *Workers Illustrated Magazine* from 1929-1938. As a result he was regularly persecuted by the National Socialist regime, spied on by Gestapo agents, and twice forced into exile because of his provocative pictures.

Seizing viewers' attentions

The goal of Heartfield's photomontages was to seize the passing gaze in a public sphere saturated by the photographic image. These photomontages sought not just to attract the eye, like a seductive consumer advertisement, but labored to stimulate political consciousness through aggressive visual means. They aimed to reveal the realities behind appearances, to take the supposedly incontrovertible "realness" of a photograph, and by cutting and reassembling photographic images and text, manipulate them to elucidate certain conditions not revealed by the original image.

The Meaning of the Hitler Salute — Millions Stand Behind Me!

The photomontage on the next page was published on the cover of *AIZ* on October 16, 1932, just two weeks before an election. It lays bare the "millions" that stand behind Adolf Hitler. Here we see capitalism, translated into corpulent excess punctuated by gleaming ring, handing a diminutive Hitler millions of Rentenmark. The small Führer hand flops back limply, rather than thrusts dynamically forward, to nonchalantly receive those millions of support.

Adolf the Übermensch

Heartfield's *"Adolf the Übermensch: Swallows Gold and Spouts Junk"* of July 17, 1932 (the opening image in this chapter) "sees through" Hitler's persuasive speeches using a technological device more potent than the photographic lens, penetrating surfaces where cameras can only record them. Through an X-Ray photograph of Hitler's insides, we discover that Hitler's entire gastrointestinal tract is clogged with coins.

Like photomontage, the X-Ray is a visual device that intervenes in the surfaces of reality in order to lay bare "true" conditions. The montage was plastered all over Berlin in anticipation for the July Reichstag elections and provoked fistfights between Nazis and Communists.

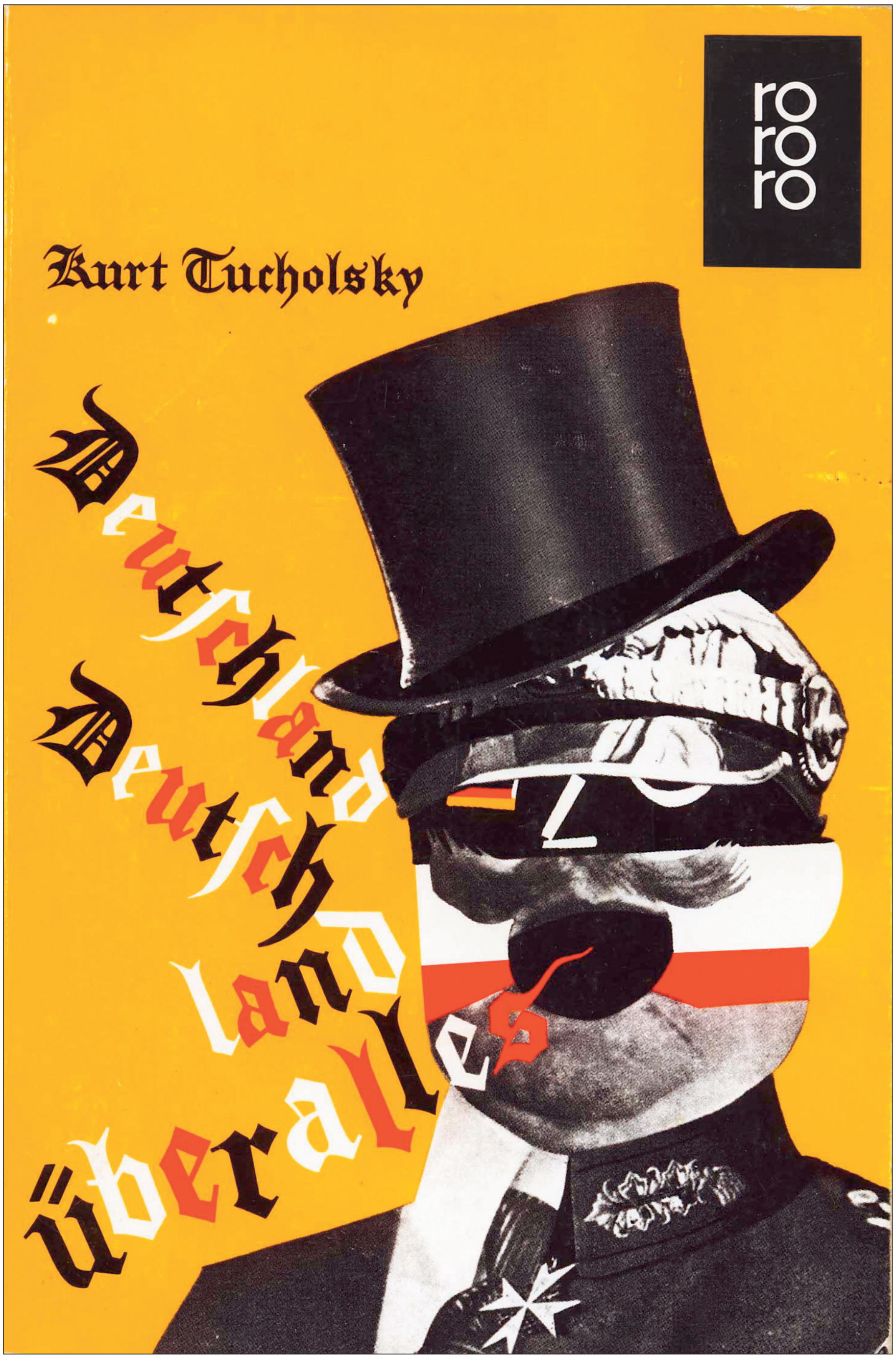
Deutschland Deutschland über Alles!

While John Heartfield gained prominence for his radical leftist photomontage, he was also greatly admired by the commercial sector, particularly for his election posters and book jacket covers.

His photomontages for the satirical book *Deutschland Deutschland über Alles!*, a text-image collaboration with the well-known author Kurt Tucholsky, was widely acclaimed and also became the focus of public controversy in 1929.

The framed print

By contrast, Heartfield's 1924 dust jacket for the collected stories of the best-selling American author Jack London is more conservative in its design and content. The montage juxtaposes a photographic portrait of Jack London, a com-


rororo
Kurt Tucholsky
Deutschland Deutschland über alles

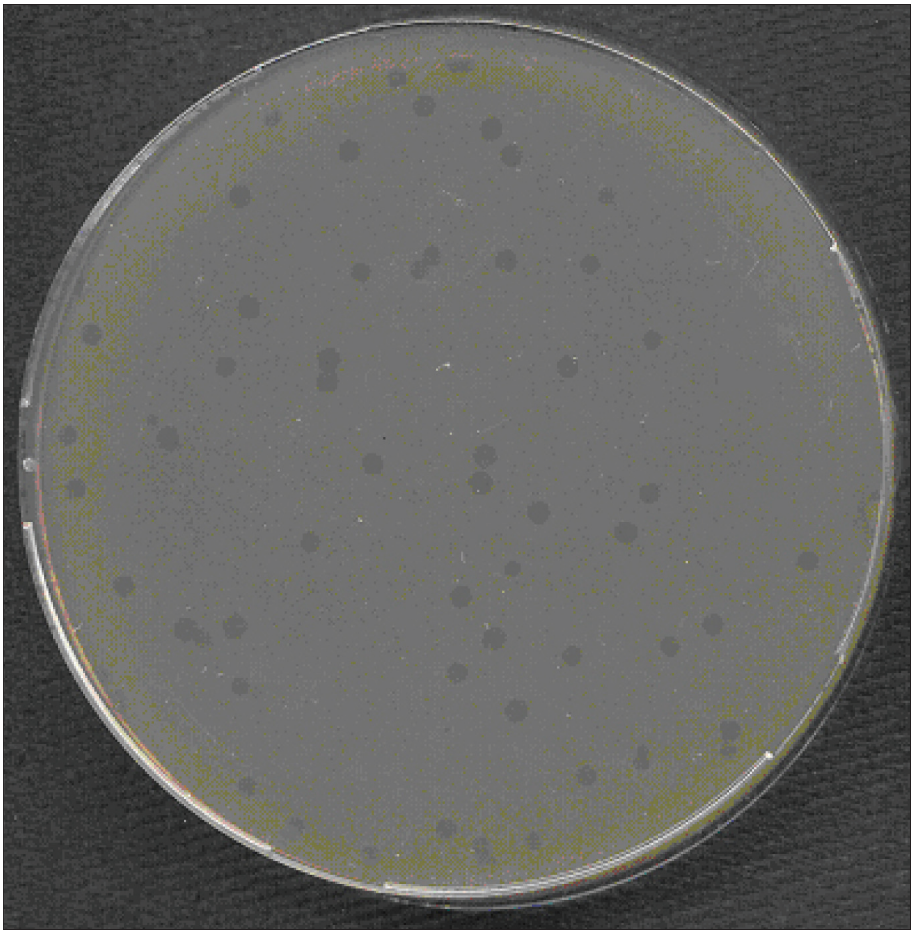
mitted socialist, with visual fragments associated with his stories of high adventure and survival. The cover montage not only reveals the book's assembled contents in a single glance but also reinforces London's leftist message of resolute and heroic struggle against a hostile environment.

Photomontage as a medium

More economical than film, more pervasive in daily life than the cinema, photomontage in the 1920s and 1930s became a political weapon, a form through which to shape mass-consciousness before radio and television were competitive forms of everyday information.

For further reading

Dawn Ades, *Photomontage* (London: Thames and Hudson, 1976); David Evans and Sylvia Gohl, *Photomontage: A Political Weapon* (London: Gordon Fraser, 1986); David Evans, *John Heartfield, AIZ-VI, 1930-1938* (New York: Kent Fine Art, 1991); and Peter Pachnicke, *John Heartfield* (New York: Harry Abrams, 1992).



27

Visualising Viruses

Stephen McGrath

The biologist Stephen Harrison wrote a book called *What Does a Virus Look Like?*. In it he considered over ten different kinds of images of viruses, made with different instruments. They are not all compatible — they cannot be assembled into one perfect picture. Harrison concluded that viruses don't "look like" anything except the sum total of those images.

William Wimsatt, a philosopher of science, has called this problem the "thicket of illustration": no one strategy will do, he notes, when it comes to picturing things as complex as DNA. Here we consider five different ways of producing images of viruses.

The plaque assay

Phages are obligate parasites of bacterial cells. They have no intrinsic metabolism and are totally inert in the absence of their bacterial hosts. They attach to the bacterial cells in a tail-first orientation, triggering the release of the DNA from the phage head, where it has been held under immense pressure.

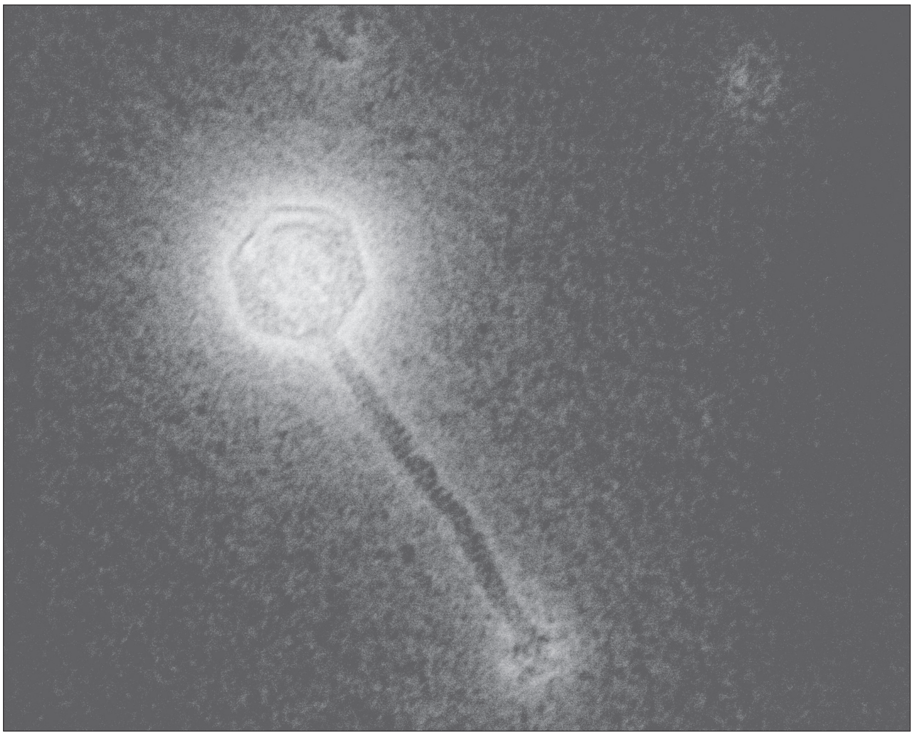
The *plaque assay* is a method used in the laboratory to visualize the bacteriophage life cycle. An agar plate is seeded with a "lawn" of bacteria that has been mixed with some phages (see opening illustration). The clear spots on the plate show where a phage has infected a bacterial cell and the progeny phages have killed the cells around it, causing a clear zone or "plaque."

At this stage, no special optical equipment is necessary to locate the phages.

Transmission electron microscopy

The main structural features of phages can be seen in the large TEM image, below. This is the lactococcal bacteriophage Tuc2009. Toward the top is the head, containing the DNA; then the tail; and at the bottom the structure that recognizes the host cells and contains the adsorption apparatus.

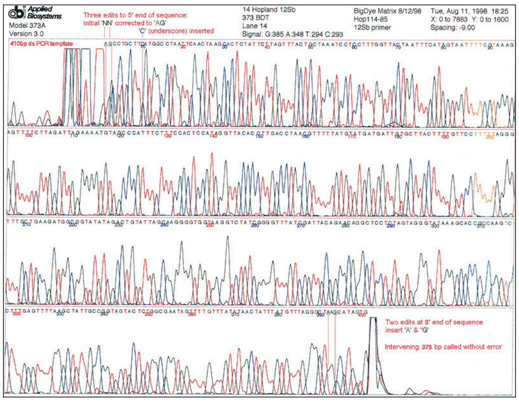
TEMs work on the analogy of light microscopes, but they shine a beam of electrons through the specimen (another example is in Chapter 21, page 212). Whatever part is transmitted is projected onto a phosphor screen for the user to see. This is a typical, full-resolution TEM image; the original is 1280 x 1024 pixels in 16-bit grayscale — these images do not need to have ultrahigh resolution.



Gene mapping

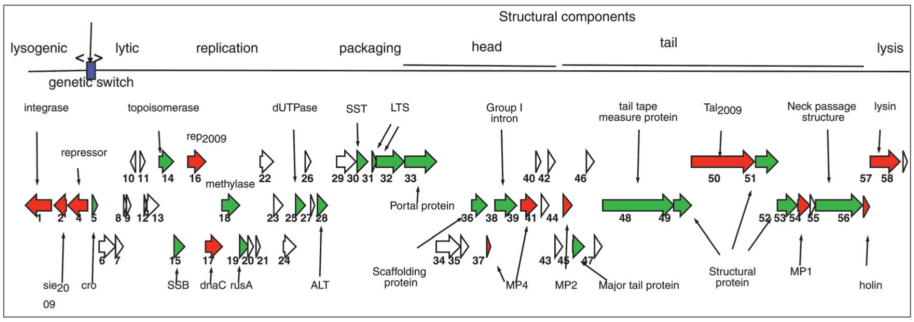
The first step in gene mapping is sequencing. The familiar base pairs of DNA — the rungs in its ladder — are sequenced. The graph that results is called a chromatogram. The names of the base pairs can be read off the graph (in five print, below the horizontal baseline); the heights of the peaks show the confidence level of the analysis.

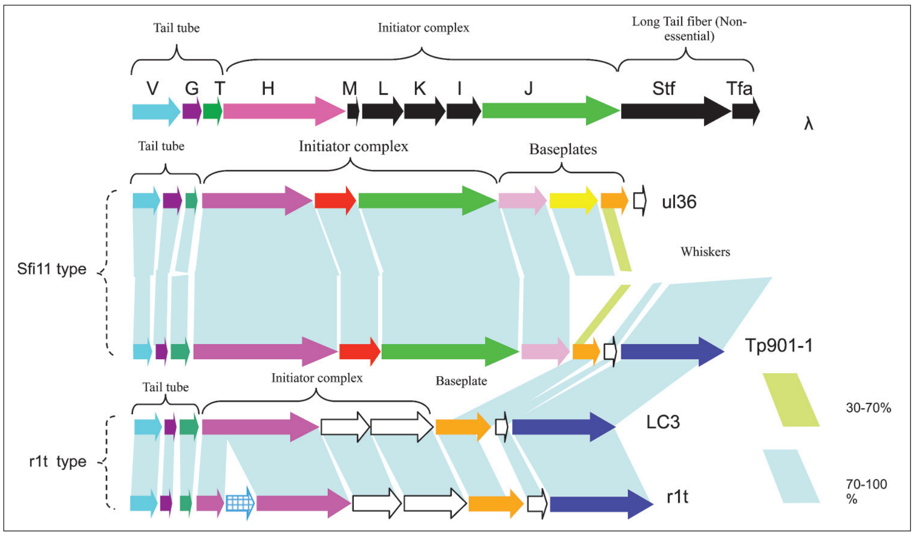
The graph reproduced below illustrates the genome of the bacteriophage Tuc2009. Its complete genome sequence has been determined and the individual



genes contained within it identified using a set of criteria based on the recognition of patterns and signatures in the DNA sequence. Each of the arrows represents an individual gene. The arrows are arranged in three rows, just to make them more visible. At the top of the image is a map of the parts of the phage that are formed by the different genes.

The coloured arrows indicate genes coding for proteins to which physiological functions have been assigned. Red indicates that a function has been assigned on the basis of experimental work,





whereas green denotes that a function has been assigned on the basis of the similarity of that protein to experimentally verified proteins encoded by other phages. Computer analysis allows us to predict which proteins will form part of the bacteriophage structure, but the actual visualization of these proteins is the only definitive proof.

The gene sequence in the Tuc2009 can then be compared with genes in other bacteriophages (diagram at the bottom of the previous page). The genes occur in slightly different places, but they can sometimes be correlated, making it possible to determine some of their functions.

Electrophoresis

The electrophoresis technique is used to separate and visualise individual proteins in a biological sample. (Compare Chapter 24, showing gel electrophoresis of cheddar cheese.)

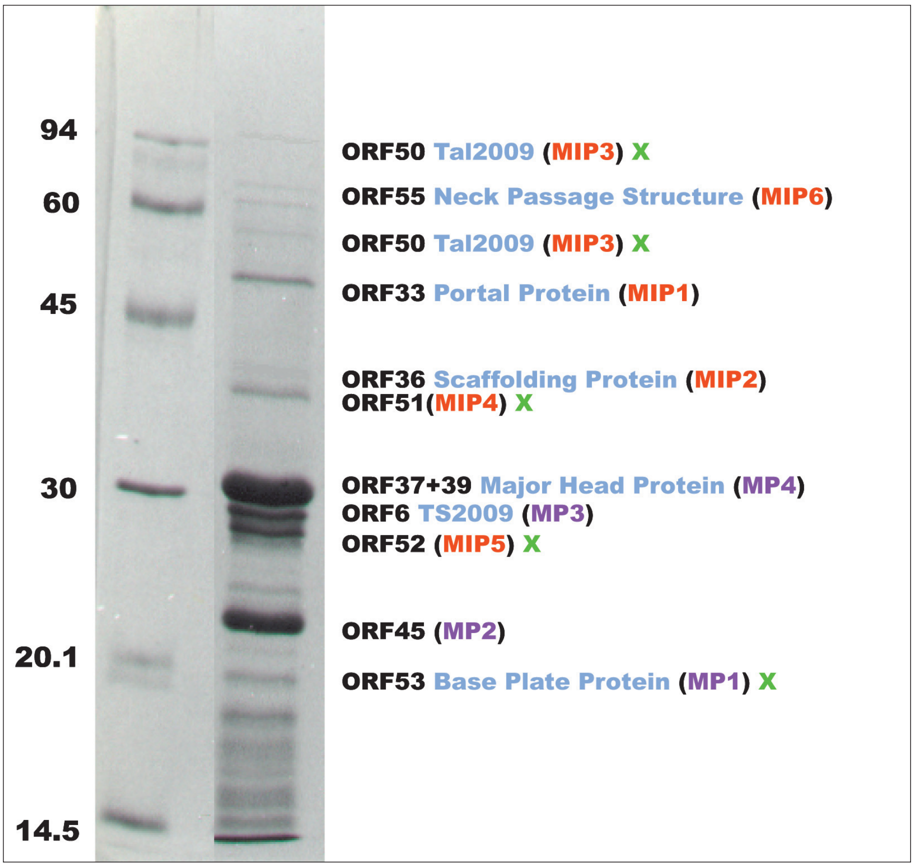
The protein bands in lane 1 (image on the next page) represent a standard mixture of proteins of known size to which test proteins are compared. Each of the bands in lane 2 represents individual proteins that constitute the bacteriophage. Single bands representing individual proteins may then be cut from the gel and further analyzed in order to determine the sequence of amino acids that they contain.

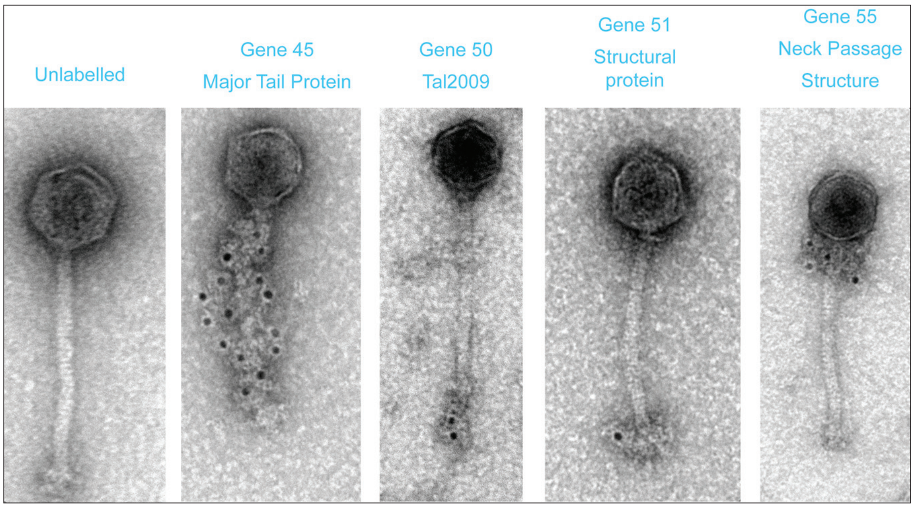
This type of analysis is dependent on the successful separation of the individual protein constituents into discrete homogenous bands as well as the presence of sufficient concentrations of proteins in these bands. The amino acid sequences may then be compared to those predicted from the gene map, thus allowing the identification of the structural proteins. You can compare the labeled protein bands in lane 2 to the arrows in the gene map (middle illustration on the previous page) to see the location of the genes that encode the proteins.

Immunogold electron microscopy

Data from the electrophoresis analysis reveals whether a particular protein forms part of the phage structure or not, but it doesn't locate the precise location of the protein on the bacteriophage. Antibodies that are highly specific for individual proteins may be generated using a variety of genetic and biochemical techniques. Labeling these antibodies with gold makes them appear as dense black spots when viewed under a transmission electron microscope. When the antibodies are mixed with the bacteriophage they specifically recognize and "tag" their cognate protein on the bacteriophage structure, thus marking the precise location of the protein.

The first panel is a TEM of the Tuc2009 bacteriophage without the addition of gold-labelled antibodies. Gold-labelled antibodies specifically recognizing


94
60
45
30
20.1
14.5
ORF50 Tal2009 (MIP3) X
ORF55 Neck Passage Structure (MIP6)
ORF50 Tal2009 (MIP3) X
ORF33 Portal Protein (MIP1)
ORF36 Scaffolding Protein (MIP2)
ORF51(MIP4) X
ORF37+39 Major Head Protein (MP4)
ORF6 TS2009 (MP3)
ORF52 (MIP5) X
ORF45 (MP2)
ORF53 Base Plate Protein (MP1) X


Unlabelled
Gene 45
Major Tail Protein
Gene 50
Tal2009
Gene 51
Structural
protein
Gene 55
Neck Passage
Structure

individual proteins are added in the other pictures and are indicated on the panels. Their encoding genes are also included — the same numbers appear on the image just above (top of p. 255).

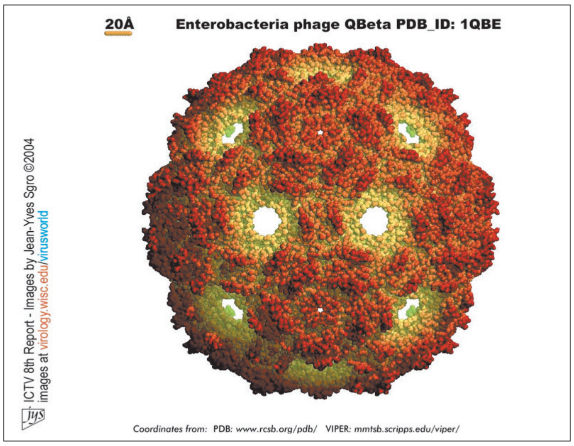
The process of generating these antibodies can be laborious and expensive, and the success of the tagging of the specific protein on the phage is dependent on a number of critical factors such as the quality of the antibody and the accessibility of the protein on the phage structure to the antibody.

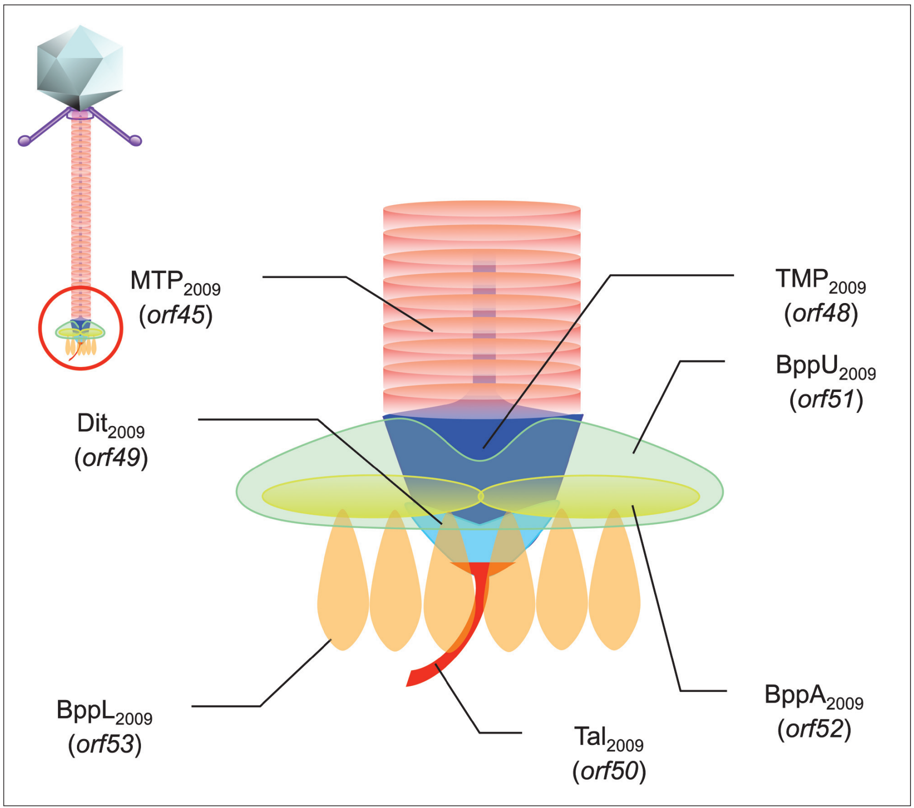
Other kinds of pictures

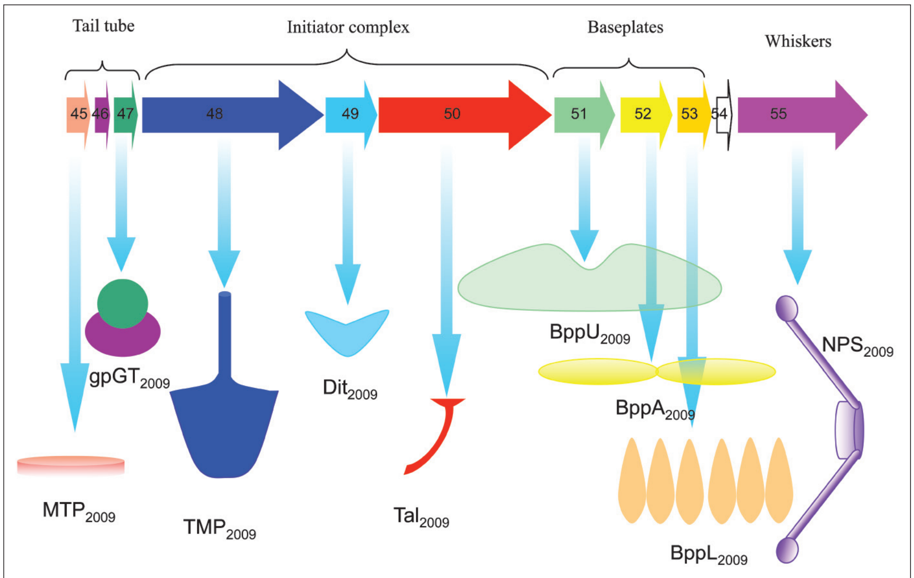
In addition to these kinds of images, virologists also make extremely detailed images of all the atoms in parts of the bacteriophages (image at the bottom of this page). At the other end of the scale of detail, virologists find it useful to make schematic pictures of the different parts of the virus, to model how they might be put together (image at the top of the next page). Ideally, each part corresponds to a known gene (photo 10).

Conclusions

These are just eight of the ten or more methods of visualizing viruses. Clearly, no single representational method is sufficient. The opposite of the "thicket" of representation is the assumption, common in fine art, that a single image — say, the *Mona Lisa* — is not only sufficient but definitional for its subject. No further representations can even be imagined, except pastiches. In this case, however, the object does not exist except as a series of partly incommensurate representations.

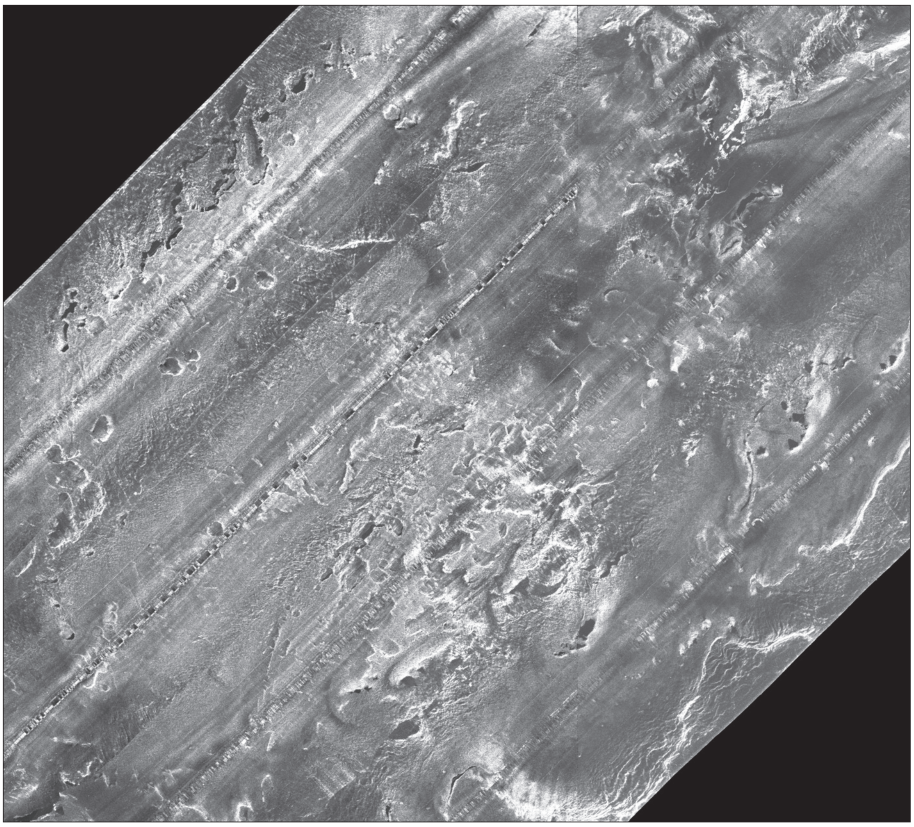



MTP2009
(orf45)
TMP2009
(orf48)
BppU2009
(orf51)
Dit2009
(orf49)
BppL2009
(orf53)
Tal2009
(orf50)
BppA2009
(orf52)


Tail tube
Initiator complex
Baseplates
Whiskers
45
46
47
48
49
50
51
52
53
54
55
gpGT2009
BppU2009
NPS2009
Dit2009
BppA2009
MTP2009
TMP2009
Tal2009
BppL2009

For further reading

More on the visualization of viruses: Stephen Harrison, “What Do Viruses Look Like?” *The Harvey Lectures* 85 (1991); James Elkins, *The Domain of Images* (Ithaca NY: Cornelll University Press, 1999), chapter 3.



28

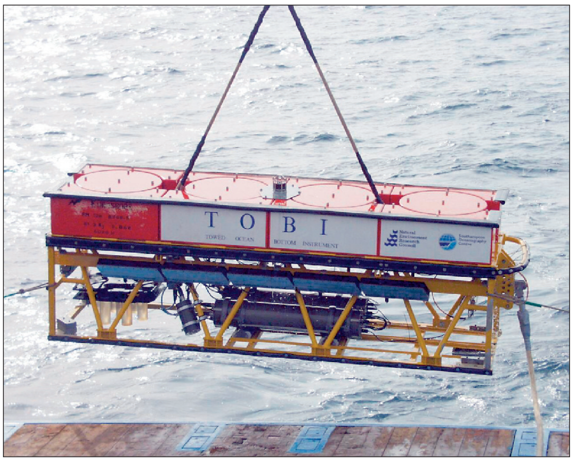
Imaging the Seabed using Side-Scan Sonar

Andy Wheeler

To image the sea floor, it is necessary to translate one kind of sensing — hearing sound echoes off the seabed — into another kind — ordinary greyscale images. Like all translations, this one produces "false friends": forms that look familiar, but are not.

How the image was taken

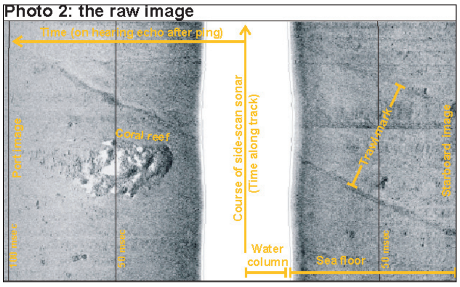
The side-scan sonar system used to acquire the image is called TOBI. TOBI weights 1.8 tons; it was towed 300 meters above the seabed, several kilometers behind the vessel. TOBI emits a ping and then listens for the return echo on two transceivers (port and starboard).



Side-scan sonar

The side-scan sonar produces raw data that can be plotted at sea in real-time. After the side-scan sonar emits a ping, the transceivers initially record silence as the sound wave travels through the water column. This is followed by the first echo from the seabed directly below sonar where it is the nearest. The echo continues, ending with the last return from the seabed furthest away on the extreme port or starboard. The

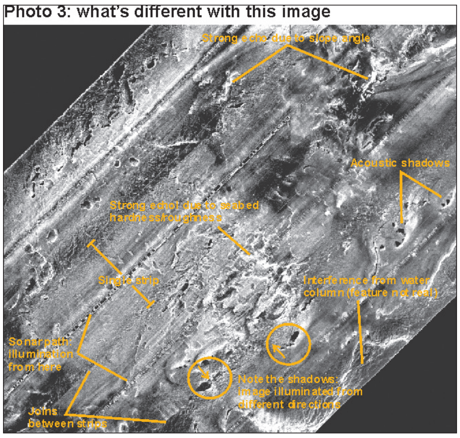
Photo 2: the raw image



time delay in hearing the echoes, measured in milliseconds, can be translated into distance from port or starboard. In this way the sonar beam scans the seabed. When the echo is fully recorded, a new ping is emitted and another echo is recorded — by that time the apparatus has moved forward so it images the next piece of the seafloor. By plotting the echoes against time in grayscale, one next to the other, a preliminary image of the seafloor is obtained.

In the photo above, the starboard image is on the right, and the port on the left. The ship travels over the seabed as shown. A gap, directly below the ship, is marked "water column." Two features of the seafloor are marked: a coral reef, and grooves left by trawling.

Photo 3: what's different with this image



What different about this image

It is tempting to look at the finished image as if it is a black and white photograph of the seabed. In fact, it is a black and white *sonograph* of the seabed that has been made from a number of strip images.

It's possible to list the features that can be misleading:

First, there is the series of diagonal lines across the image following the path of the sonar. (They do not indicate features of the seafloor.)

Second, there are fainter lines where the strips join. (Marked at the bottom of photo)

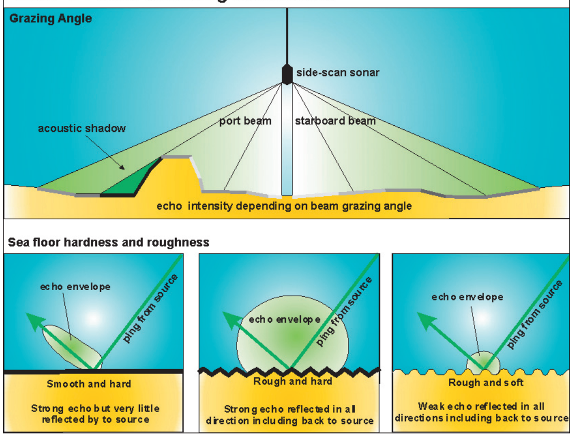
Third, there are shadows, but they do not behave in a familiar fashion.

Sonar shadows

Each strip is illuminated from the center (from the sonar path) out to the edge so that acoustic shadows (like normal shadows) fall to the left and right of this line. When the strips are put together, the new image is illuminated by sound in a very unusual way: from the center of each strip rather than from one direction only.

More oddities

Photo 4: Factor affecting backscatter



Fourth — continuing the list of things that aren't "normal" about this image — the interpretation of bright and dark areas also differs from how we would see a black and white photo. Dark areas are formed from seabed that returns weak echoes and bright areas from seabed that gives back strong echoes.

In a similar way to photographs, this is partly caused by slope angle (grazing angle): steep slopes facing the sonar path are bright (like sunlight slopes) and slopes facing away are dark. However, strong echoes (bright values) can also be formed by hard or rough seabed, which reflects more sound.

The bottom of this diagram shows even more complexities of hardness and roughness. The image at the bottom of the previous page shows a couple of the permutations (middle and top). This does not correspond well with ordinary objects illuminated by light: this image has to be *learned* before it can be seen.

And one last oddity

Fifth, an illusion is formed when sound is bent (or diffracted) by density differences in the water column producing a series of wavy lines due to echo return clustering. This is apparent at the edge of imaged strips where the echo has had to travel the furthest. It is marked on the lower right of the labeled photo at the bottom of the previous page.

How the image is assembled and cleaned up

To produce the final image, the raw data from the side-scan sonar needs to be processed. First, the port and starboard images are stitched together by removing the silent "water column." This has been done large image.

Next, across-track time has to be converted to across-track distance based on the speed of sound through water. Then, along-track time has to be converted to along-track distance based on the tow speed of the sonar and the ping-rate.

The image then has to be "navigated" — its global position fixed — based on ship's position (as determined by satellite) and the distance of the sonar behind the vessel. The overlaps between the outer edges of adjoining strips are neatly cut together. The entire image can then be enhanced to maximize density contrasts.

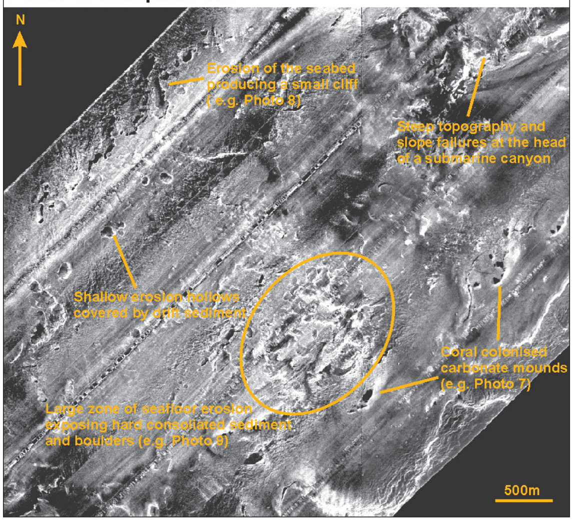
What is the topography?

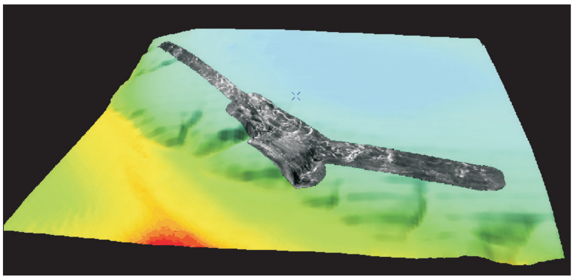
When the image is complete, the trained eye can start to interpret the seabed features. There are two main difficulties with interpretation.

First, the image contains no topography so it can be difficult to tell if a change in grayscale is due to a change in slope, a change in seabed type, or both. This can be overcome by draping the image over a topographic reconstruction of the seabed obtained by depth soundings using different acoustic techniques. In the image at the bottom of this page, submarine canyons not obvious on the side-scan sonar become clearly visible. (Notice the canyons in this overlay, and compare them with the same features on the large image.)

Second and more fundamentally, the image is still only a grayscale image, reflecting differences in the intensity of the echo. In theory the same echo intensity can be generated by a soft but rough bottom and a hard but smooth bottom. The geologist makes a contextual interpretation, but that is only an experienced guess until it is confirmed (or "ground-truthed") by the collection of physical seabed samples or seabed photographs.

Photo 5: interpretation





The purpose of the study

This seabed mapping was undertaken to make the remote accessible. The sonar image provides a map that can be used by others to explore the seabed. The image has the advantage of not only showing seabed features but also the nature of the seabed sediment; that information is impor-

Photo 7: Irish coral reef with crinoids and fish

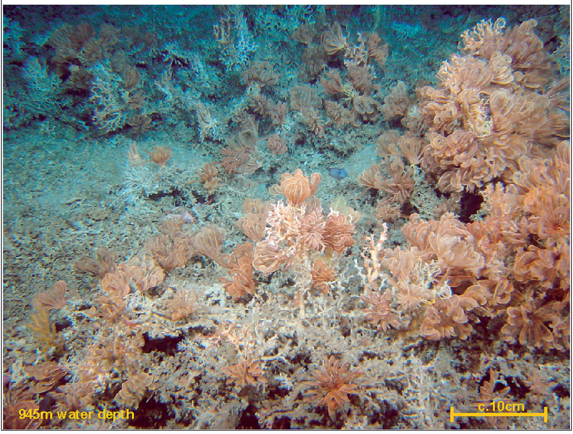


Photo 8: coral colonised top of submarine cliff

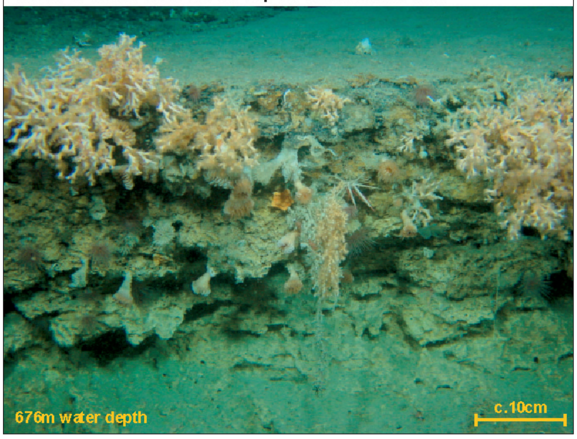
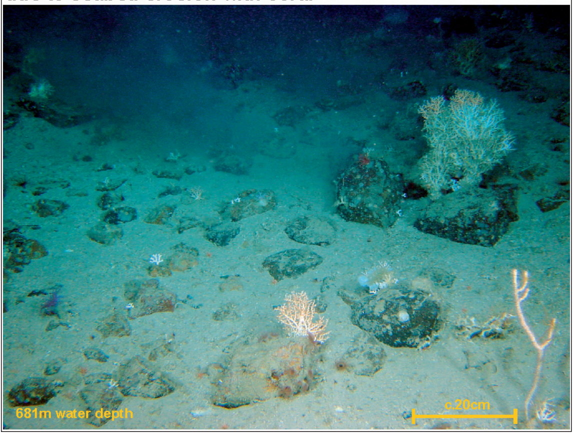


Photo 9: typical seabed showing exposure of boulder due to seabed erosion with coral



tant to fishermen trawling the seabed, marine mineral prospecting companies including oil companies, submarine cable layers and engineers who need to install seabed structures. Side-scan sonar can also be used to hunt for shipwrecks and salvage or check submarine dump sites.

The reason the university made this particular image was to understand what was happening in a particularly harsh environment where we suspected deep-water corals thrived. Following the creation of the image, a follow-up survey was undertaken "ground-truthing" interesting areas with sediment samples and video cameras mounded on a robotic submersible. Those images, shown with their original exhibition captions on the previous page, proved and refined our geological interpretations.

For instance, the bottom photo shows a boulder-strewn seabed. The boulders are too small to be seen by the side-scan sonar but they account for the strong return signal observed in that area. Without the video imagery we could only have said that there was a hard seabed there — possibly a rock platform, boulders, or something else.

Conclusion

There are two lessons here for the uses of the visual. First, as we have seen in Chapters 6,10 and 16, an image that appears to be an ordinary picture may not be. In this case, it may be necessary to elaborately re-train the eye to interpret such fundamental things as light and shade. Second, although the side-scan sonar allows us to map large areas and extract useful information it takes experience to read the results. The proof — "ground-truthing" — is a relatively simple photograph, video, or sediment sample. Mapping, here, precedes seeing.

For further reading

See first the website: www.marine-group.com/SonarPrimer/SideScanSonar.htm; then Andre M. Akhmetzhanov, Neil H. Kenyon, Micheal K. Ivanov, Andy Wheeler, Pavel V. Shashkin, and Tjeerd C.E. van Weering, "Giant Carbonate Mounds and Current Swept Seafloors on the Slopes of the Southern Rockall Trough," in *European Margin Sediment Dynamics: Side-scan Sonar and Seismic Images,* edited by Jurgen Mienert and Phil Weaver (Berlin: Springer Verlag, 2003), 203-210; Doug G. Masson, Brian J. Bett, Dave S.M. Billett, Colin L. Jacobs, Andy J. Wheeler and Russel B. Wynn, "The Origin of Deep-Water, Coral-Topped Mounds in the Northern Rockall Trough, Northeast Atlantic," *Marine Geology* 192 (2003): 215-37; Andy Wheeler, Maxim Kozachenko, Andres Beyer, Anneleen Foubert, Veerle A.I. Huvenne, Michael Klages, Doug G. Masson, Karine Olu-Le Roy and Jorn Thiede, "Sedimentary Processes and Carbonate Mounds in the Belgica Mound Province, Porcupine Seabight, NE Atlantic," in *Deep-Water Corals and Ecosystems,* edited by Andre Freiwald and J.Murray Roberts (Berlin: Springer Verlag, 2005), 571-603.

СТОЛПЪ И УТВЕРЖДЕНІЕ ИСТИНЫ.

FINIS AMORIS, UT DUO UNUM FIANT.
ПРЕДѢЛЪ ЛЮБВИ—ДА ДВОЕ ЕДИНО БУДУТЪ.

29

Metaphors of Light and Dark in Arabic and Russian Philosophy

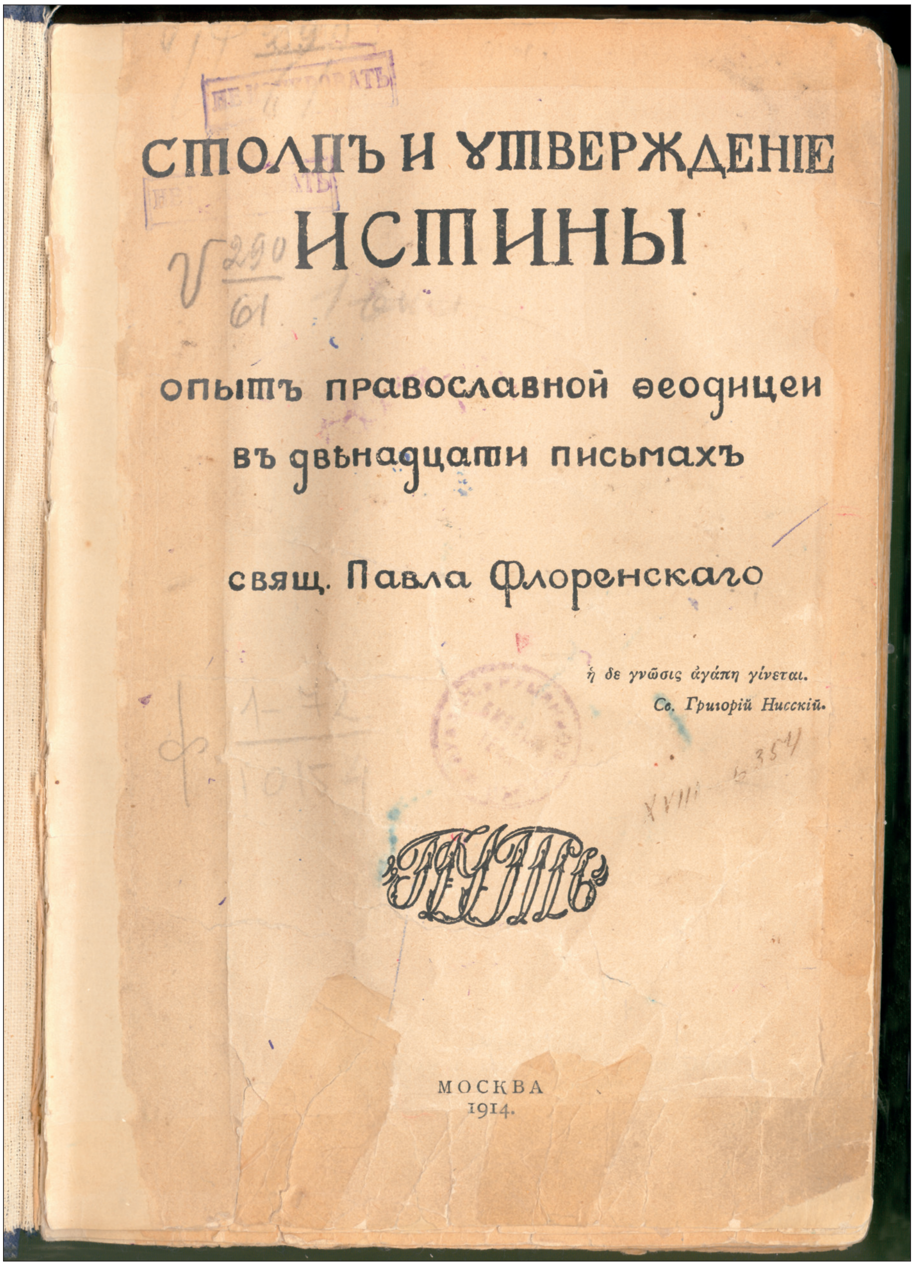
Anna Zenkova

Philosophy is shot through with optical metaphors. Hegel's use of optical metaphors is discussed in Borch-Jakobsen's book *Lacan: The Absolute Master.* In the book by Martin Jay *Downcast Eyes: The Denigration of Vision in Twentieth-Century French Thought* the role of vision and optical metaphors in western philosophy, particularly France, was investigated. I will consider just two examples out of the hundreds possible: Arabic Peripatetic philosophy and philosophy of Illumination, and Russian *fin-de-siècle* philosophy.

Pavel Florenskiy

The book illustrations here are of Florenskiy's *The Pillar and Ground of the Truth: An Essay in Orthodox Theodicy in Twelve Letters.* He designed the cover himself, including the fonts, and the book is self-published. The legend under the two angels, *Fenis amoris ut duo unum fiant* ("Love makes two into one") is intended to express his principal metaphysical claim: the assertion that all created coexist with each other. Consider these three key terms in his text:

Truth (истина, estina)
Darkness (темнотиа, temnota)
Clearness (ясность, yasnost')



СТОЛПЪ И УТВЕРЖДЕНІЕ
ИСТИНЫ

опытъ православной ѳеодицеи
въ двѣнадцати письмахъ

свящ. Павла Флоренскаго

ἡ δὲ γνῶσις ἀγάπη γίνεται.
Св. Григорій Нисскій.

ПУТЬ

МОСКВА
1914.

In Florenskiy's work, the true "act of seeing" opposes false distanced seeing. Florenskiy suggests the ontological aspects of idea and knowledge by using the example of the Russian word "truth" (истина, *estina*). He noted that the word descends from Latin verb *est* (истина: that which exists). The important factor of sense-building in Russian philosophy, he argued, is the difference "egoistic false seeing," that is "the darkness" (темнота, *temnota*) and "living true seeing," that is joint action in which subject and object flow together in "the clearness" (ясность, *yasnost'*). The egoistic concentration of self on itself leads to neuropathological conditions, namely a condition of "being in darkness" and being "separated from whole world."

Hence the opposition between "true seeing" and "false seeing" is more significant than the opposition "visible" and "invisible," or between "obvious" and "hidden". Florenskiy argues that the perception of objects takes place intuitively, and is a direct contemplation of living reality as it is in itself: it is "the act of inner union of perceiving person and perceivable object." The question about true seeing becomes a question about the true observer and his or her place in the world. The "true seeing" is a perceptible joining of subject and world in common action. To be is "to be revealed"; and "to reveal" is to find truth.

Prozrachnyj and prizrachnyj

Transparency (прозрачный, *prozrachnyj*)
Spectral (призрачный, *prizrachnyj*)

Another important conceptual difference between West European and Russian philosophy is between transparency and the spectral or mirroring function in epistemology. In Russian "transparency" (прозрачный, *prozrachnyj*) and "spectral" (призрачный, *prizrachnyj*) have similar pronunciation. According to Florenskiy transparency isn't just a requirement of cognition, it is the highest human value. This value is as unavoidable as our desire for being in the world. Because of the ontological orientation of nineteenth-century Idealist Russian philosophy the metaphor "transparency" was gradually transformed from "transparency of the environment in which the object is located" to "transparency of the object."

By means of transparency the eye is like the light: it can penetrate body of matter. But true insight begins when the object that is recognized is understood as transparent. Understanding the play of transparent surfaces is understanding the inner and outer aspects of the object.

The Peripatetics and The Ishraqiyun

As a second example, consider terms in Arabic Peripatetic philosophy and Philosophy of Illumination. I will use texts by two famous representatives of the two schools: the Arabic Peripatetic al-Farabi, who had the name "Second Teacher" (after Aristotle); and the founder of the Philosophy of Illumination (the *Ishraqiyun*) al-Suhrawardi, who developed the Peripatetics' ideas.

Zuhir and batin (photo 3)

visible *zahir* ظاهر	
invisible *batin* باطن	

visible (*zahir* ظاهر)
invisible (*batin* باطن)
Manifest or (*zahir*) and latent or invisible (*batin*) are meta-categories in Arabic philosophy. Relations of the visible and the invisible in Arabic philosophy of the 10^{th} and 11^{th} centuries correspond neither to the dichotomy of truth and falsehood (as in Russian philosophy) nor to the dualism of appearance and essence. The distinction of visible and invisible, *zahir* and *batin,* exists in discussions of latentness as opposed to manifestness (or visibility) in the causality of the earlier Mutakallimun (a school that includes Abu al-Hudhail al-'Allaf, al-Ash'ari, Mu'tamir and others). This question was studied in detail by representatives of Peripatetic philosophy, and the philosophy of light or illumination (the *ishraqiyun*). Here I will not consider the differences among the schools, but concentrate on what they have in common.

The ontological aspect of the relation between *zahir* and *batin* is investigated in the *Book of Gems (Kitab al-fusus* كتاب الفصوص *)*. The author of this book, Al-Farabi (878-950), is considered to be the follower of Peripatetic philosophy. In the *Kitab al-fusus,* manifestness (called *zahur* ظهور) is understood as the explicitness of all consequences — that is, grades of being — of the First Cause. Without explicitness First Cause annot be in itself; it must remain invisible. It is impossible to say that one thing can manifest the First Cause in full measure. Its latentness consists of its invisibility *as* itself.

So manifestness as visibility and latentness as invisibility are impossible without one other and lead to one other. The perception of a thing is the movement from visible to invisible and not the other way around.

Light of lights	
Nur al-anvar	الانوارنور
Close light	
Nur al-akrab	الاقربنور
Victorious light	
Kahir	قاهر

Nur al-anvar, nur al-akrab, kahir

Light of lights (*Nur al-anvar* نور الانوار)
Close light (*Nur al-akrab* نور الاقرب)
Victorious light (*kahir* رهاق)
Metaphors of light and dark specific to Arabic philosophy can be found in texts by the founder of the Philosophy of Il-

lumination al-Suhrawardi, most important of them is *The Wisdom of Illumination* (*Himkat al-ishraq* حكمت الاشراق). According to the doctrine of Philosophy of Illumination everything consists of lights and their shadows, which emanated from the absolute unity of the *light of lights* (*Nur al-anvar*). For the Neoplatonic chain of emanations of minds (or intellects or angels), al-Suhrawardi substituted with his own chain of emanations of lights coming from united the light of lights, which he took to be identical with the Absolute (*almotluk* المطلق). According to al-Suhrawardi the total number of links in this chain of emanations is much more than the ten traditional grades of Peripatetic thought, which are a traditional element of Peripatetic doctrine.

The first emanation of Great Light (*nur al-a'zam*) al-Suhrawardi calls Archangel Brahman or "close light" (*nur al-akrab*). Because there is no barrier between it and the Light of Lights, the radiance of the Great Light falls directly to the Light of Lights. As a result of this fall and radiance there arises a new victorious light (*kahir* رهاق) on which fall both the Great Light and the First Light that are above it.

On the third light falls the second light (twice), Great Light, First Light, and so on. The perception of a thing which appears, according to the Philosophy of Illumination, as "irradiation," is the perception of a particular light that is one of the potentially endless aspects of God (*Allah* اللّه) or Truth (*hakika* حقيقة).

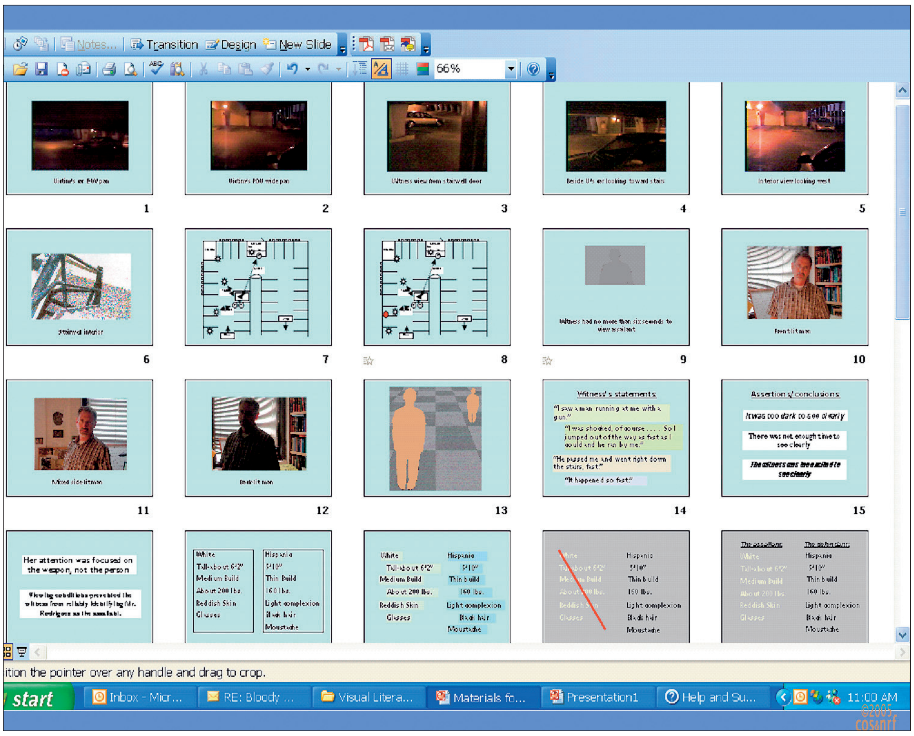
Conclusions

It is interesting to note that there are many investigations devoted to the analysis of visual metaphors in West European philosophy, but that Arabic and Russian philosophic texts have never been analyzed from this standpoint. I think that analysis of the ways of conceptualizing visual metaphors in different philosophical traditions can serve as a modest starting point for a comparative history of metaphors of visuality, and I hope I have suggested that at least some elements in Russian and Arabic philosophy are visual in a different way than the apparently "natural" visuality that is being celebrated today in the West.

For further reading

Florensky, *The Pillar and Ground of the Truth: An Essay in Orthodox Theodicy in Twelve Letters* (Princeton NJ: Princeton University Press, 1997); Florenskiy, *Анализэ пространственности и времени в художественно-изобразительных произведениях (Analysis of Space and Time in Art and Pictorial Production)* (Moscow, 1993); Florenskiy, *мнимости в геометрии* (*The Imaginary in Geometry* (Moscow, 1922); Al-Suhrawardi, *Hikmat al-ishraq / Oeuvres philosophiques et mystiques de Shihabeddin Yahya Sohrawardi*, edited by Henry Corbin, *Bibliotheque Iranienne*, vol. 2 (Teheran and Paris: Institut Franco-Iranien–Librairie d'Amerique et d'Orient, 1952), 2-260; Vladimir Lossky, *The Mystical Theology of the Eastern Church* (London: J. Clarke, 1957); A. Smirnov, *Логика смысла: теор-*

ия и ее приложение к анализу классической арабской философии и культуры. (*Logic of Sense: Theory and its Implementation to the Analysis of Classical Arabic Philosophy and Culture)* (Moscow: Languages of Slavic Culture, 2001); D.M. Dunlop, "Al-Farabi's Paraphrase of the Categories of Aristotle," *The Islamic Quarterly: A Review of Islamic Culture* 4 (1957): 168-83, ans also 5 (1959): 21-37; L.I. Vasilenko, L. I., "O magii i okkultizma v nasledii o. Pavla Florenskogo" (On Magic and Occultism in the Heriage of Father P. Florensky), in *Vestnik Pravoslavnogo Sviato-Tihonovskogo Gumanitarnogo universiteta* (Moscow, 2005), vyipusk 3.


Transition
Design
New Slide
66%
Witness's statements
Assertion/conclusions
Her attention was focused on the weapon, not the person
ition the pointer over any handle and drag to crop.
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Inbox - Micr...
RE: Bloody ...
Visual Litera...
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Help and Su...
11:00 AM

30

Teaching Visual Rhetoric to Law Students

Neal Feigenson and Christina Spiesel

Increasingly, Anglo-American legal advocates are combining images and words in computer animations, PowerPoint slide shows, and interactive CD-ROMs to present their evidence and their arguments (see also Chapter 7). To function effectively in this digital multimedia world, law students and lawyers need to develop a critical visual intelligence that enables them to anticipate the cognitive and emotional effects of word/image displays and to respond to their adversaries' presentations. They will rarely have time to research the images that they and others make, and they must be prepared to exercise their own judgment under time pressure rather than to rely on "authoritative" readings — quite different from the discipline of art history or the legal convention of arguing from precedent.

The goals of the workshop

We have several years' experience teaching visual literacy and argumentation in a one-semester course for law students, and in a considerably more condensed format to practicing lawyers. These law students and lawyers may or may not have had any prior visual training or art education. We expect that, by the end of our course, they will be able to draw on a wide range of verbal and visual materials to inform their construction of sophisticated and persuasive multimedia arguments in hypothetical (but highly realistic) cases. The teaching that is designed to get them to that point is guided by the following principles:

1. Students best learn visual literacy primarily by doing visual work (as opposed to merely being told about or shown it) and then articulating responses to what they and their classmates have done. (I.e., the learning is mainly bottom-up and experiential — which is quite nontraditional in legal education.)

2. Students best develop a reciprocally creative and disciplined approach to visual work by doing both non-case-specific (i.e., in our course, not tied to a specific legal task) and case-specific projects.

3. Students use a particular visual technology most effectively when they see it as one among many tools in a wide-ranging visual rhetorical toolkit rather than as a presentational imperative. Particular technologies come and go; a critical visual intelligence cuts across these and, following Aristotle's definition of rhetoric, chooses the one(s) most suitable to the task at hand.

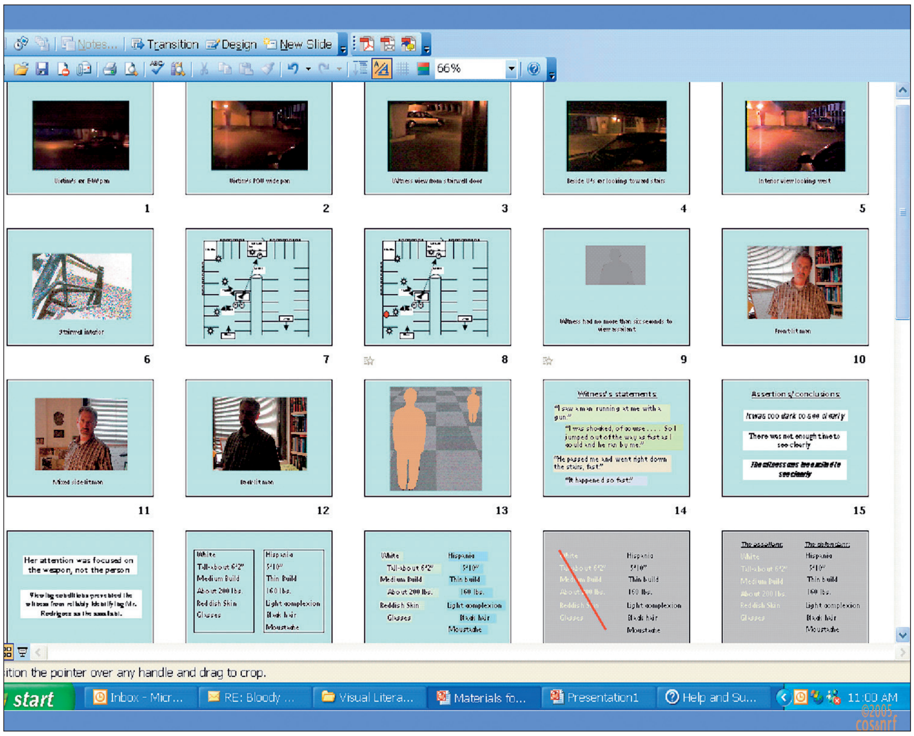
4. An open and collaborative classroom setting develops future professionals' abilities to work in groups, to learn from focus groups and colleagues, and thus to refine their verbal/visual "texts" to make them more effective for their intended audiences.

The workshop

Participants in our workshops are invited as a group to use PowerPoint as a tool for thinking visually and exploring different word-image combinations. We place them in the role of attorneys representing the defendant in a simulated criminal case — an assault and robbery in a parking garage at dusk — and ask them to construct a visual argument, in the form of a PowerPoint slide show, that would be used to accompany an oral closing argument on behalf of the defendant.

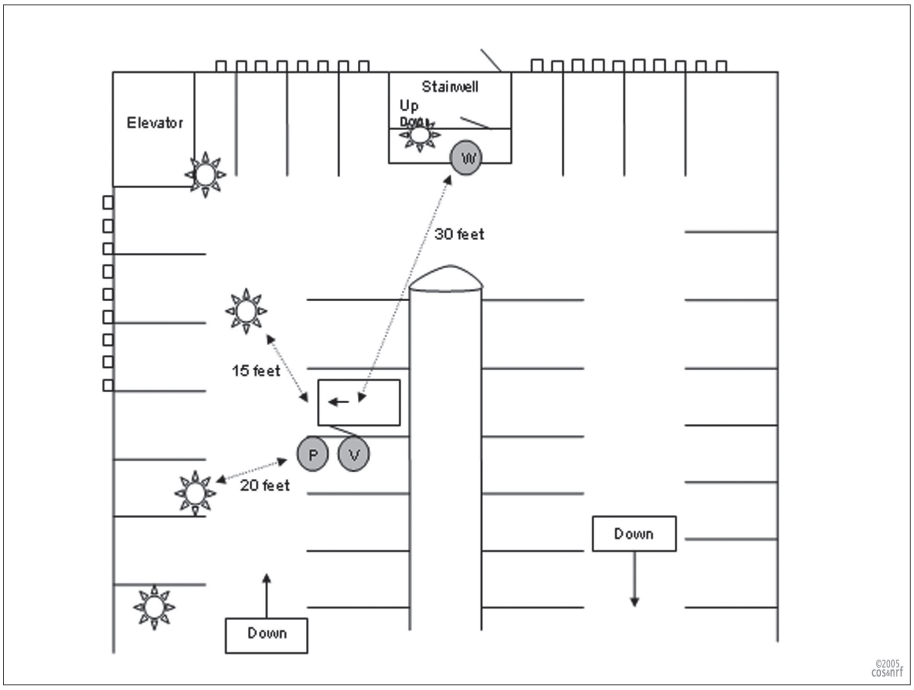
The case poses issues of eyewitness identification readily understandable by non-lawyers. These include how viewing conditions in the garage (for instance poor lighting, the rapidity of the crime) may have undermined the reliability of the witness's later identification of the defendant as the perpetrator, and how the many discrepancies between the witness's initial description of the assailant to the police and the defendant's actual physical characteristics (e.g., height, weight, race) implied that the defendant could not have been the person the witness saw. We give participants a brief description of the case and their role, and then provide them with a menu of materials that they can incorporate into their visual argument, including photos, video clips, and diagrams of the crime scene, document excerpts, sample texts, and other information from the case file (photo 1). Working as a group, participants suggest elements to be incorporated into each slide; we construct the slides as they variously direct. As each new element is proposed, the group reviews and discusses the display, and thus progressively reconfigures, deletes items from, and adds more elements to the work in progress.

We organized one such workshop at the conference that was the starting point of this book; the group of participants at the conference workshop generated many ideas for visualizing the argument, engaging in a lively discussion of both the impact of individual slide designs and the pros and cons of alternative argument strategies. Some favored a paradigmatic approach, beginning with words that framed the argument as a whole (e.g., the viewing conditions argument, fol-

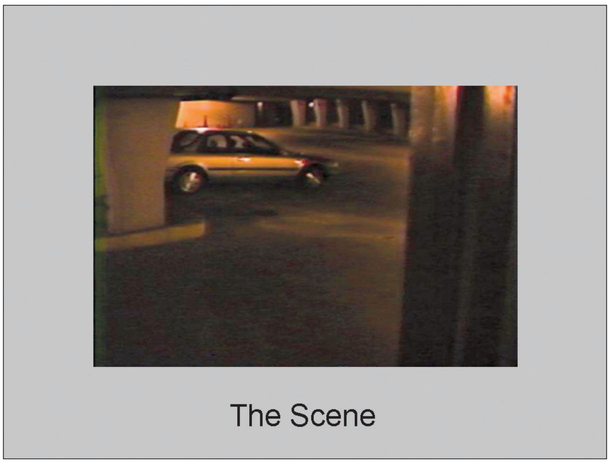


lowed by the argument based on the discrepancies) and complemented by a diagram of the crime scene that laid out the spatial relationships among perpetrator, victim, and witness. Some, by contrast, preferred a narrative, even cinematic, approach that immediately plunged the audience into the ill-lit garage where the crime occurred. The group sought to accommodate the two strategies by starting with the diagram (reproduced on the next page) and then using a video clip to put the audience at the crime scene (a frame is shown at the bottom of the next page). By the end of the time allotted for the workshop, however, the group was unable to concur on a complete argument sequence.

It is instructive to compare the conference participants' (incomplete) construction with the visual arguments that emerged from two other iterations of the workshop which we offered on other occasions. Both of these other slide sequences began with a view of the garage to launch the contention that viewing conditions prevented any reliable identification of the perpetrator; both then designed text, with or without images, to emphasize the discrepancies between the witness's description of the perpetrator and the defendant's actual characteristics. Otherwise, however, the two sequences followed very different visual logics.

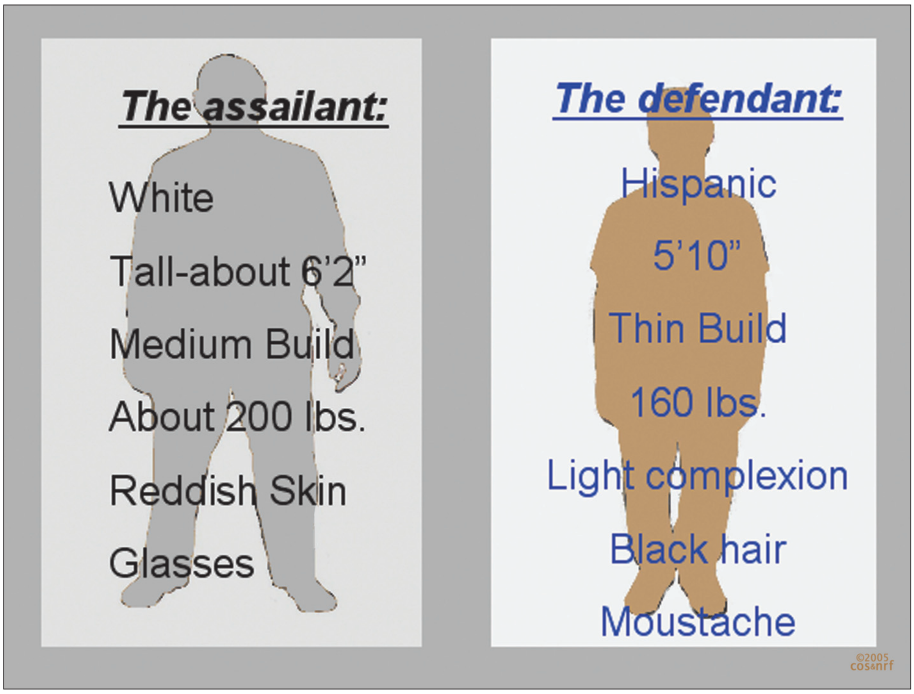


Interior view looking west



The first sequence

The first sequence began with a still photo of the garage from the witness's point of view (above). The addition of a simple caption, "The Scene," cued the audience to anticipate a dramatic presentation — in this case, a visual closing argument conceptually located at the crime scene. The second slide presented contrasting

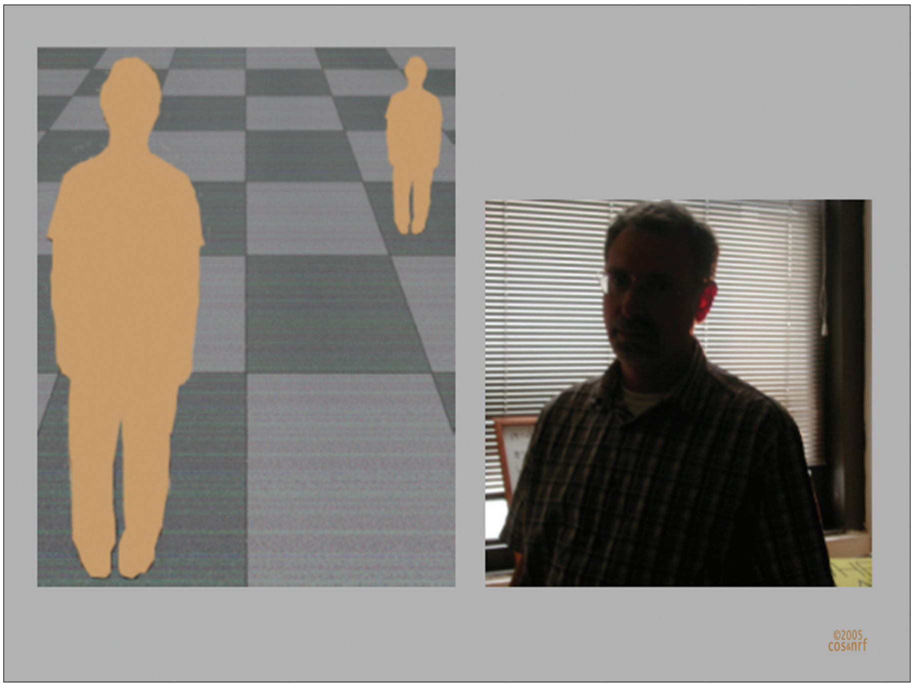


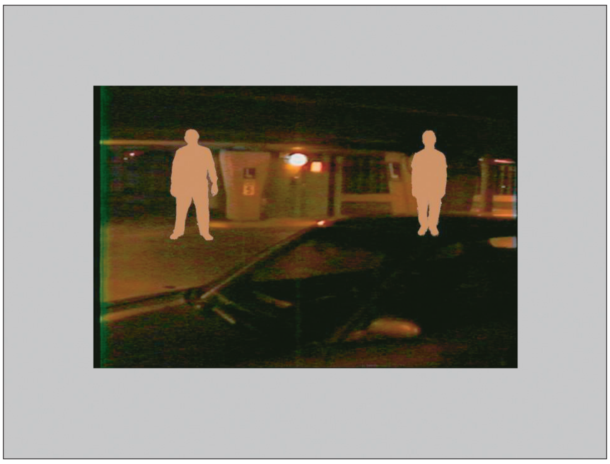
lists of the features of the assailant as the witness initially described him to the police and the defendant's actual features, as if to argue that viewing under such poor lighting conditions (as depicted in the first slide) could naturally lead to great discrepancies between an eyewitness's description of the assailant and the person whom the police happened to arrest. The simple text lists provided in the workshop materials were animated and overlaid on contrasting silhouettes of two men, underscoring the divergence between the man the witness saw at the scene and the defendant.

The third slide consisted of a pair of demonstrations: how small a figure seen at 30 feet (the initial distance between witness and perpetrator) appears compared to a figure seen at close range, and how indistinctly the facial features of a back-lit person (such as the perpetrator as seen by the witness) can be seen (shown below).

The sequence concluded by returning to the dark garage interior, this time in a video clip, on which perspectivally small versions of the silhouettes of the perpetrator and the defendant were superimposed (see the illustration on the next page).

This final montage culminated a highly conceptual approach to the case that relied on visual demonstrations of arguments (e.g., the difficulty of perceiving clearly in poor lighting) rather than being confined to a strategy of simple veri-



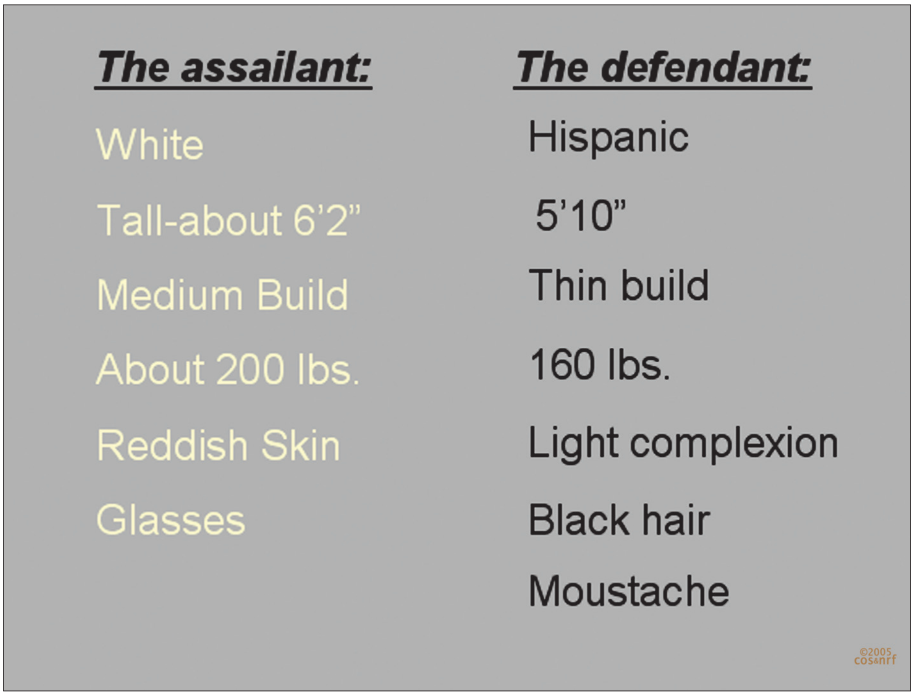


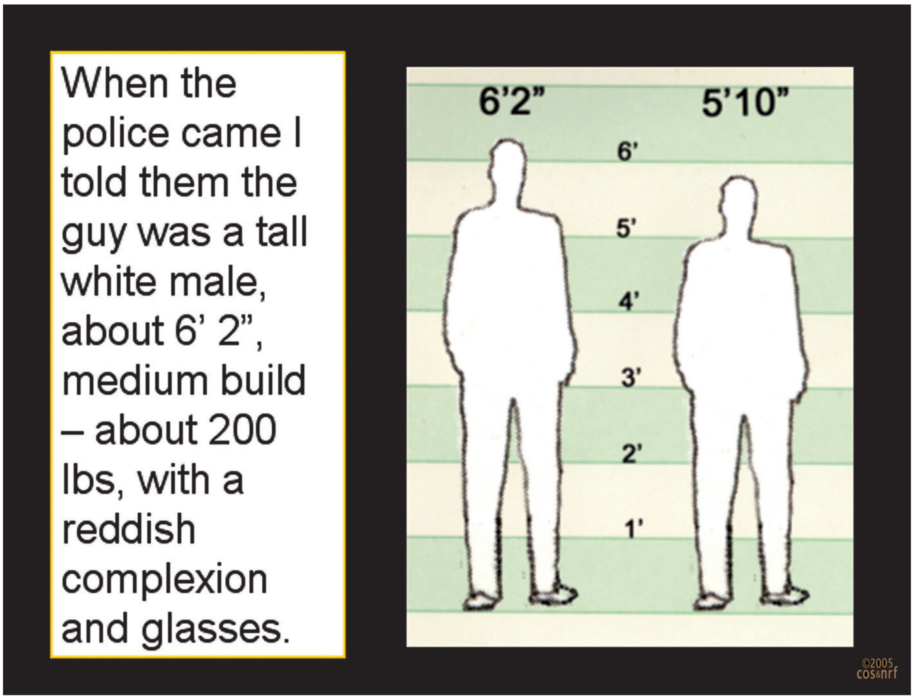
similitude. The repetition of the iconic silhouettes — first linked to text, then to a diagram, and finally placed back in the crime scene — artfully constructed a visual through-line for the entire argument: Given that place and those conditions, a witness might readily think that she saw one man but actually have seen another, very different man.

The second sequence

The second sequence, like the first, began in the poorly lit garage, but with a video clip rather than a photo, thus immersing judge and jury in the crime scene even more vividly (top illustration on the page). This sequence then moved to the contrasting lists of physical characteristics, presented without the silhouettes or other iconic adornment (bottom of the next page). A third slide combined an animated text of the witness's initial description of the assailant with a diagram comparing the described height to the defendant's actual height, thus emphasizing both the witness's confidence in her own initial identification and the vast differences between that description and the defendant (top illustration on the page 285).

At this point this workshop group, which consisted of law professors and law students, observed a subtle rhetorical problem in the otherwise effective argument strategy so far: How to get the jury to reject the witness's identification of the defendant as the perpetrator without seeming to disparage the jury's natural tendency to identify psychologically with the victim and the witness (rather than with the perpetrator or the defendant)? In other words, the first three slides explained that poor viewing conditions can undermine eyewitness accuracy, but also posed a question: How could a presumably reasonable and clear-headed


The assailant:
White
Tall-about 6’2”
Medium Build
About 200 lbs.
Reddish Skin
Glasses
The defendant:
Hispanic
5’10”
Thin build
160 lbs.
Light complexion
Black hair
Moustache


When the police came I told them the guy was a tall white male, about 6' 2", medium build – about 200 lbs, with a reddish complexion and glasses.
6'2"
5'10"
6'
5'
4'
3'
2'
1'
©2005 cos&nrf


12/1/03
Second photo array
©2005 cos&nrf

witness be so wrong? The group nicely resolved this dilemma with a final slide (created from additional case materials): The photo arrays that the police showed to the witness, and on the basis of which she identified the defendant as the perpetrator, were biased to elicit just that response (bottom illustration on the previous page). The entire argument sequence thus combined words and images to construct a compact problem-solution narrative — the story of a mistaken eyewitness and a falsely accused defendant — that tied together all of the defendant's major contentions in a way that would lead the jury both to decide in the defendant's favor and to feel a comfortable sense of resolution in having done so. This is the very objective of legal argument, and participants achieved it by envisioning it: They combined words and images in different ways and revised their own creations until they saw their "theory of the case" in front of them.

Outcomes

For educators in visual studies, communication studies, and other curricular areas, our interactive workshop provided three main rewards. First, it gave participants ideas for helping students to experience the fluidity with which images and words can be made to interact and the various meanings those interactions produce, an essential insight for understanding effective communication and persuasion in law or any other domain of today's visual culture. Second, the workshop modeled how teachers can flexibly deploy the resources of the most widely available presentation software in the world without being constrained by the program's too-familiar defaults. Third, we demonstrated a teaching method that began with prepared materials but did not significantly confine participants' responses to those materials; rather, the structure and the task freed participants to be inventive, to exchange their visual ideas with others, and to revise their work in light of their own and the group's shared perceptions.

Visuality in the law

The strategic uses of visual rhetoric in law is a field made possible in part by the confluence of literary theory and law, starting with Stanley Fish's work in the 1980s. One of the other books to come out of the Cork conference, *Visual Literacy,* contains an essay by Richard Sherwin, of the New York Law School, on the elaborate problems posed by such things as videos of crimes that may, or may not, be faked "art films" inspired by films such as *The Blair Witch Project.* In this book, Chapter 7 deals with the investigation of a complex incident, which is now — as the event recedes in history and memory — increasingly dependent on intricate visual reconstructions. Visual rhetoric in law is a rapidly growing field, and an excellent opportunity for fields such as literary theory, sociology, psychology, rhetoric, art, and art history, to begin a wider conversation. It is an invitation to a genuinely interdisciplionary, and preeminently *visual* conversation: and in that respect a fitting note on which to end.

For further reading:

Christopher Buccafusco, "Gaining/Losing Perspective on the Law, or Keeping Visual Evidence in Perspective," *University of Miami Law Review* 58 (2004): 609-651; *Visual Persuasion in the Skakel Trial: Enhancing Advocacy through Interactive Multimedia Presentations,* edited by Brian Carney and Neal Feigenson *Criminal Justice* 19 no. 1 (2004): 22-35; Costas Douzinas and Lynda Nead, *Law and the Image* (Chicago: University of Chicago Press, 1999); Neal Feigenson, "Digital Visual and Multimedia Software and the Reshaping of Legal Knowledge," in *Images in Law*, edited by W. Pencak and A. Wagner (London: Ashgate, c.2007); Jennifer Mnookin, "Reproducing a Trial: Evidence and its Assessment in *Paradise Lost*," in *Law on the Screen,* edited by A Sarat, L. Douglas, and M. Umphrey (Stanford, CA: Stanford University Press, 2005), 153-200; Christopher Ritter, *Creating Winning Trial Strategies and Graphics*. Chicago: American Bar Association, 2004); Christina Spiesel, "A *Las Meninas* for the Law," in *Images in Law*; and Spiesel and Feigenson, "Law in the Age of Images: The Challenge of Visual Literacy, in *Contemporary Issues of the Semiotics of Law*, edited by A. Wagner, T. Summerfield, and F. Benavides (Oxford: Hart Publishing, 2005), 231-55.

Afterword

So that ends the sample of thirty departments, thirty different ways of making and interpreting images. I will not add to the theorization I offer in the Introduction, except to say that I hope the "particulate" form of this book now makes sense. The world of visual practices is wide and deep, and if we are to understand it, we have to explore, like the first generations of linguists did, and learn to speak some of the languages used outside the enclave of the humanities.

It may surprise some North American and other English-language readers that this book is published by Wilhelm Fink. Among North American scholars, the normal protocol is to try to publish with a North American university press. If I were a younger scholar, and this was my first book, I would not have published it outside the US, and even within the US I would have tried to publish with one of the very small number of "top" academic presses interested in the history of art and science: University of California, Yale, Princeton, Cornell, Harvard, MIT, Johns Hopkins, Penn State Press, or the University of Chicago. For some scholars I know, that list is even shorter. If they can't place their books with one of those presses, they may wait for opportunities to place chapters in the equally small number of major journals, or in specialized anthologies. The only alternatives to the short list of US presses are normally Cambridge, Oxford, Routledge UK, Yale (London), and perhaps Reaktion. A North American scholar working with French materials might also seek to co-publish her book with Minuit, Flammarion, Gallimard, or another French publisher. A North American scholar working on a German subject might try to find a publisher in Germany. But even in those cases, the books would be co-published (for example, by Flammarion and Yale University Press); and in fact very few English-speaking scholars in the humanities try to co-publish on the Continent. This book is doubly unusual, therefore, because it is not being co-published in the United States.

The reasons are somewhat delicate, but worth exploring. First it needs to be said that English speakers often read only in English. Some European publishers are not considered serious even if they publish in English, and even if they are based in England. Ashgate, Palgrave, and Sage, for example, are popular among scholars in the UK, but they might be considered second-tier choices by scholars in the US. A North American art historian, seeing a book published by Ashgate or Palgrave, might well assume that the manuscript had been rejected by North American presses. (That notion is, in my experience, wholly confined to North America, and no such stigma attaches to Ashgate or Palgrave in the UK.) This cultural prejudice and scholarly isolationism means that even excellent German presses such as Wilhelm Fink, Wagenbach, Suhrkamp, and Riemer are virtually invisible, and largely unknown, in North America. (And so are newer presses such as Turia und Kant and Diaphanes, which are very roughly like Macula in

France and Reaktion in the UK: that is, they might be inadvisable choices for young scholars in the US who need a major press for their first publication.[1]) Because they generally do not sell many books, German academic publishers do not advertise widely, retain aggressive international distributors, or attend book fairs. As a result, German academic publishers are not well represented in North American academic conferences or university bookstores. (That non-participation is also due to the different ethos of academic publishing in Germany, which is less commercially oriented than in the US. This book is has a very small print run and is subsidized in order to keep the retail price at a reasonable level. However, the subsidy alone would put it out of reach of most young scholars in the US or UK who were looking to publish their first book.[2]) Those few Continental presses that are known in the US, Australia, and the UK — Prestel, for example, which has offices in New York — are considered to be less scholarly.

North American scholars intent on their careers, who need to be taken seriously among their academic colleagues, generally avoid presses other than the University of California, Yale, Princeton, Cornell, and the others I've mentioned; and books published by any other presses — and especially those on the Continent — will be looked on skeptically, as if they are either irrelevant or second-rate because their authors had failed to publish with a first-rank US publisher.

Why, then publish this book with Wilhelm Fink? For three reasons.

1. Most research on science and non-art images is done in German-speaking countries and in Scandinavia. The word *Bildwissenschaft* has recently been revived, by Horst Bredekamp and others, to describe an historical approach to the study of images that stresses non-art and technical images.[3] (In English-language scholarship, *Bildwissenchaft* has recently been given an entirely different valence.[4]) Images outside of art have been theorized by a number of German, Austrian, and Swiss scholars including Joël Sakarovitch, Wolfgang Pircher, Karin Leonhard, and especially Peter Geimer.[5] In Basel, Gottfried Boehm and others have initiated a project called Eikones, which also aims at an inclusive study of all images.[6] In Scandinavia a similarly inflected study of non-art images is called "visual studies," and it goes by other names as well — "iconic criticism," "image studies," "image science."[7] It's pertinent, also, that the "iconic turn" in German scholarship (associated with Boehm, who coined the expression in 1994) is different from the "pictorial turn" in English-language scholarship (associated with W.J.T. Mitchell, who coined it in 1992).[8]

The names do not matter as much as what is studied. Visual studies in English-speaking countries, and in places influenced by them, is restricted much more tightly to fine art and popular art. There are several emergent differences between scholarship inspired or informed by the "iconic turn" and scholarship informed by the "pictorial turn," among them the wider sense of *Bild* in German, as opposed to English *picture;* but in effect, the German literature of the last ten years has been significantly more involved with the particulars of "epistemic" or "technical" images outside of art. As I mentioned in the Introduction, this book was originally to have been published along with the proceedings of a conference called "Visual Literacy." The conference proceedings, which will appear as two separate books — *Visual Cultures* and *Visual Literacy* — reflect the state of visual studies in mainly Anglophone countries. Despite the wide range of papers, there is virtually no science in those two books. (The principal exception is an essay by Matthias Bruhn and Vera Dünkel, members of the unit called "Das Technische Bild" at the Humboldt-Universität in Berlin.[9]) The near-absence of non-art images from the two other conference books is not happenstance, but structural: the number of scholars in North America and the UK who study non-art images is very small. One might name Lisa Cartwright among visual studies scholars, and there are Martin Kemp, Linda Dalrymple Henderson, John Gage, and a half-dozen others in art history. Journals like the *Journal of Visual Culture* are uniformly uninterested in image-making outside of mass culture and fine art.

This book, therefore, is partly a response to visual studies as it is known in Anglophone countries. I am concerned that the field restricts itself too much to images in popular culture and fine art. The wider world of image-making practices is usually only acknowledged by pointing to the social construction of science — its entanglement in politics, gender, identity, and the society that provides its institutional structures. What is missing in that approach is really nothing less than the visual languages of science and other non-art practices. This book is meant as a sampler of the kinds of complexity that inhere in visual practices when they are considered in detail. Hence the first reason for publishing with Wilhelm Fink: Germany is in the part of the world where visual studies has the best chance of becoming the broad-based, university-wide field that it should be.

2. There is a custom in publishing in the humanities, according to which books should be continuous narratives, uninterrupted by problem sets, equations, and graphs. In the long-standing tradition of humanist scholarship, such books are for the "general reader"; they are intended to be non-technical even if they involve special lexica and jargon. I sent this book, in manuscript, to two prominent university presses in North America, before I decided a German press is more appropriate. In both of the US presses, the Acquisitions Editors rejected the manuscript on the grounds that it was too technical. As I mentioned in the Introduction, one editor said it was too "particulate," by which she meant not sufficiently woven into a single continuous narrative. (She recommended I write the thirty chapters into a single text on the model of the Introduction.) As I argued in the Introduction, it is wholly appropriate and deliberate that this book is partly fragmentary, "particulate," and technical. Those qualities are meant as responses to the uniformly non-technical, undetailed exposition of non-art images in more Anglophone scholarship.

3. In the US and other countries, some university presses are inclined away from elementary pedagogy. They see it as their purpose to produce professional-level research and books that drive disciplines forward. Textbooks are mainly thought to be the domain of specialized publishers. One of the US editors who saw this book in manuscript thought it might make a good first-year textbook, but felt that the pedagogic purpose made it unsuitable for a university press. Of course there are exceptions to this rule (many university presses in the US also publish textbooks) but for the most part, textbooks are handled by non-university, "trade" publishers. This book is again a special case. I would be glad if it were used as a textbook: I used a working version of it to teach this material in Ireland, to first-year undergraduates, with some of the authors as guest speakers. It is certainly amenable to that approach. But it is also intended as an experiment, a way of pushing a little on the field of visual studies to see what it might look like if it takes first-year education seriously. For that reason I thought an academic publisher would be appropriate.

Those are the reasons this book was published in Germany. I hope that this gesture suggests that visual studies should be as international as possible. The kinds of visual studies practiced in the US, Canada, Australia, New Zealand, and the UK (and in countries influenced by them) can learn a lot from the highly detailed, technophilic visual studies practiced in German-speaking countries and in Scandinavia. The opposite is also true: the emphasis on politics and identity that are the cornerstones of English-language scholarship have already had interesting effects on German-language writing. There are also ways of practicing visual culture beyond the ones I have mentioned. There is a kind of visual studies in South America that comes in part from communications theory and semiotics, and a kind in the People's Republic of China that intersects with aesthetics and cultural heritage. By publishing this book in Germany, I hope to suggest that the conversation on visual studies can be broader and more challenging than it sometimes has been.

It seems to me that restricting visual studies to art and popular culture risks missing a tremendous opportunity. Visual studies can become the place where images and visuality are studied for the entire university, and not just for the humanities. To do that, it is necessary to spend time considering unfamiliar visual practices *in detail*, and not as examples of other practices to which they may not be directly related.

Notes to Afterword

1 I thank Wolfram Pichler for pointing me to Turia und Kant and Diaphanes.

2 This book has a print run of 500, augmented with 100 personal copies for distribution. A typical visual culture or science studies book in the US would have a print run of 2,000 to 3,000, approximately 280 copies of which go to the principal university libraries in the US and UK.

3 See first Bredekamp and Pablo Schneider, "Visuelle Argumentationen — Die Mysterien der Repräsentation und die Berechenbarkeit der Welt," in the book of the same title, edited by Bredekamp and Schneider (Munich: Wilhelm Fink, 2006), 7-10; and for an excellent example of the confluence of technical and historical analysis of images, see his *Darwins Korallen: Due frühen Evolutionsdiagramme und die Tradition der Naturgeschichte* (Berlin: Klaus Wagenbach, 2005). Bredekamp's argument about *Bildwissenschaft* was made for an English-language readership in "A Neglected Tradition? Art History as *Bildwissenschaft*," *Critical Inquiry* 29 no. 3 (2003): 418-29. See further *Bildwissenschaft: Disziplinen, Themen, Methoden,* edited by Klaus Sachs-Hombach (Frankfurt a.M.: Suhrkamp, 2005); and the review by Carolin Behrmann and Jan von Brevern, in *ArtHist: Netzwerk für Kunstgeschichte im H-net,* 9 November 2005, www.arthist.net/DocBookD.html, November 2006, which has an interesting summary of aproaches to pictures.

4 The word *Bildwissenschaft* was appropriated by W.J.T. Mitchell in a talk given at the conference that originally was to be published along with the material in this book. In *Visual Literacy* (New York: Routledge, 2007), Mitchell uses the word to describe some fundamental properties of visual interpretation. It is a newly-minted sense, however, not meant to be connected to the German usage.

5 I thank Wolfram Pichler for bringing my attention to Sakarovitch and Pircher. See Sakarovitch, *Epures d'architecture: de la coupe des pierres à la géométrie descriptive XVIe-XIXe siècles* (Basel: Birkhäuser, 1998*); Kunst, Zeichen, Technik: Philosophie am Grund der Medien,* edited by Marianne Kubaczek and Wolfgang Pircher (Münster: LIT, 2004); *Ordnungen der Sichtbarkeit: Fotografie in Wissenschaft, Kunst und Technologie* (Frankfurt a. M.: Suhrkamp, 2002); *Was ist ein Bild?,* edited by Gottfried Boehm (Munich: Wilhelm Fink, 1994). For Leonhard see for example "Was ist Raum im 17. Jahrhunderts? Die Raumfrage des Barocks: Von Descartes zu Newton und Leibniz," in *Visuelle Argumentationen: Die Mysterien der Repräsentation und die Berechenbarkeit der Welt,* edited by Horst Brekedamp and Pablo Schneider (Munich: Wilhelm Fink, 2006), 11-34; and Leonhard, *Das gemalte Zimmer: Zur Interieurmalerei Jan Vermeers* (Munich: Wilhelm Fink, 2003).

6 Eikones (National Centres of Competence in Research [NCCR] "Bildkritik" or "Iconic Criticism") is a Swiss National Science Foundation project, which began in October 2005. As of autumn 2006, it was divided into six modules, studying different aspects of the image including images in literature, architecture, anthropology, science, and engineering. The modules were organized according to a range of conceptual frameworks: iconophilia and iconoclasm, the "power of images," the generation of meaning, image politics, visualization, the epistemic image (principally scientific images), memory, aporetic images, and a number of others. As of this writing (March 2007) the project is in early stages, and most of the material is unpublished aside from NCCR publicity materials, which are partly on the website, www.eikones.ch.

7 For references see my *Visual Studies: A Skeptical Introduction* (New York: Routledge, 2003), chapter 1.

8 In the German literature, see *Iconic Turn: Die neue Macht der Bilder,* edited by Hubert Burda and Christa Maar (Cologne: DuMont Literatur und Kunst, 2004), and the review by Carlin Behrmann and Jan von Brevern, in *ArtHist: Netzwerk für Kunstgeschichte im H-net,* 2 November 2005, www.arthist.net/DocBookD.html, November 2006. In addition to sources cited above, see *Logik der Bilder: Präsenz — Repräsentation — Erkenntnis,* edited by Richard Hoppe-Sailer, Claus Volkenandt and Gundolf Winter (Berlin: Reimer, 2005), especially the introduction "Logik der Bilder," pp. 9-16.

9 The essay is in the book *Visual Literacy* (New York: Routledge, 2007).

Contributors

Francis Burke is Senior Lecturer/Consultant and Head, Department of Restorative Dentistry, The University Dental School and Hospital, Cork. His main interests are teaching operative dentistry and oral care for the elderly. His publications include "Progressive Changes in the Pulpo-Dentinal Complex and Their Clinical Consequences," *Gerodontology* 12 no. 2 (December 1995): 57-66. He is currently the President of the British Society of Gerodontology (2005) and Past-President (2000-2002) of the Irish Division, International Association for Dental Research. (Department of Restorative Dentistry, University Dental School and Hospital, Wilton Cork, f.burke@ucc.ie)

David O'Byrne works at the Department of Computer Science at University College Cork, Ireland.

Paul Callanan teaches Physics and Astronomy in the Department of Physics at University College, Cork. His research concerns the study of very compact stars —including black holes — in our Galaxy, across the range of the electromagnetic spectrum. He has used many of the world's largest telescopes to this end, and very much agrees with Einstein that "the most incomprehensible thing about the universe is that it is comprehensible."

John Carey is a lecturer in the Department of Early and Medieval Irish, University College Cork. His publications include the books *King of Mysteries: Early Irish Religious Writings* (Dublin, 1998) and *A Single Ray of the Sun: Religious Speculation in Early Ireland* (Andover & Aberystwyth, 1999). He is preparing a study of colour taxonomy and colour symbolism, as these are reflected in certain Old Irish texts. (j.carey@ucc.ie.)

John Considine lectures in the Department of Economics, University College, Cork. His publications include "Constitutional Interpretation: Edmund Burke and James Buchanan and their 18th Century Intellectual Roots," *Constitutional Political Economy* 17 (2006): 71-85; "The Simpsons: Public Choice in the Tradition of Swift and Orwell," *Journal of Economic Education* 7 no. 2 (2006): 17-228; and (with Seamus Coffey and Daniel Kiely) "Irish Sports Capital Funding: A Public Choice Perspective," *European Sports Management Quarterly* 4 no. 3 (2004): 150-69.

James Elkins teaches at the School of the Art Institute of Chicago, and is Manager of Events and Publications at University College Cork, Ireland. His most recent books include *Visual Studies: A Skeptical Introduction* (New York, 2003), *On The Strange Place of Religion in Contemporary Art* (New York, 2004), *Master Narratives and Their Discontents* (New York, 2005), and the edited volumes *Photography Theory* and *Is Art History Global?* (New York, 2006). (mail@imagehistory.org)

Neal Feigenson is Professor of Law at Quinnipiac University School of Law and Research Affiliate in the Yale University Department of Psychology. He is the author of *Legal Blame: How Jurors Think and Talk about Accidents* (Washington, DC, 2000). Other recent publications include "Emotions and Attributions of Legal Responsibility and Blame: A Research Review" (with Jaihyun Park), *Law and Human Behavior* 30 (2006): 143-161; "Too Real? The Future of Virtual Reality Evidence," *Law and Policy*, 28 (2006): 271-293; and "Law in the Age of Images: The Challenge of Visual Literacy" (with Christina Spiesel and Richard Sherwin), *in Contemporary Issues of the Semiotics of Law,* edited by Anne Wagner, Tracy Summerfield, and Farid Benavides (Oxford, 2005), 231-255. (275 Mt. Carmel Avenue, Hamden, CT 06518; feigenson@quinnipiac.edu)

Paul Fletcher is Professor of Speech and Hearing Sciences at University College Cork. He held previous academic appointments at the Universities of Reading and Hong Kong. His research interests are in language development and language imapirment in children; he has published widely on these topics in relation to children learning English and Chinese. Among his book-length publications are *A Child's Learning of English* (1986), *Language Acquisition*, edited with Michael Garman (1989); and *Developmental Theory and Language Disorders,* edited with Jon Miller (2005).

Robert Fourie lectures in the Department of Speech and Hearing Sciences at University College Cork. He has worked variously as an audiological scientist and speech and language therapist for deaf children. His publications include "Frequency Specificity and Oto-Acoustic Emissions" (Johannesburg, 1992), 19-21; "Efficiency Of A Hearing Person Learning Sign Language Vocabulary From Media versus A Teacher" (East Yorkshire, 2002), 45-60; and "Language Planning Issues in the Education of Deaf Children" (Dublin, 2005), 96-108.

Catherine Gorman works at the Department of Restorative Dentistry at University College Cork. She lectures in dental technology to both undergraduate and postgraduate students. Her publications include "The Influence of Some Different Factors on the Accuracy of Shade Selection," *Journal of Oral Rehabilitation* 31 no. 9 (2004): 900-4; "Heat-Pressed Ionomer Glass-Ceramics, Part I: An Investigation of the Flow and Microstructure," *Dental Materials* 19 (2003): 320-26; and Part II *Ibid.* 20 (2004) 252-61.

Bettie Higgs is a lecturer in the Department of Geology at University College Cork, Ireland. Her areas of interest include plate tectonics and the use of geophysics to investigate the subsurface. In addition she tutors geology to non-traditional students in the Centre for Adult and Continuing Education, and the Open University. She is interested in the public understanding of science, and coordinates activities designed to support staff in their teaching and learning role in UCC. (b.higgs@ucc.ie)

Eithne Hunt lectures in the Department of Occupational Therapy, University College Cork. Her teaching and research interests centre on the relationship between daily occupations and health and well-being.

Hugh Kavanagh is an Architectural Technician and Surveyor. He graduated as an Architectural Technician from Waterford I.T in 1995 before working with Ben Murtagh on conservation works at Reginald's Tower, Waterford city and at Kilkenny Castle; in 1999 he joined Valerie J. Keeley Ltd. as an AutoCAD Technician, working on large infrastuctural works such as the N9 Dublin to Waterford motorway and Carrickmines Castle, Dublin. He has worked with the Archaeological Services Unit at the University college Cork since 2003. His publications include graphic work for Excavations in Cork 1984-2000; the Keiller Knowles Collection by Peter Woodman; and a number of articles for the *Journal of the Cork Historical and Archaeological Society.* He has designed graphics and presentations for the European Association of Archaeologists, Cork County Council and UCC. He is an associate member of the Association of Archaeological Illustrators and Surveyors.

Sabine Kriebel is a Lecturer in History of Art at the University College Cork. Before coming to Ireland, she worked at the National Gallery of Art, Washington DC in a postdoctoral capacity where she collaborated on a major exhibition of Dada and assisted in the Department of Photographs. She is currently writing a book on the 1930s photomontages of John Heartfield. Her publications include "Theorizing Photography: A Short History," the Introduction to *Photography Theory*, edited by James Elkins (New York: Routledge, 2006); "Die Gestaltung der Ruine: Caspar Walter Rauh und die Nachkriegszeit," in *Caspar Walter Rauh: Schwierige Verzauberung,* exhibition catalogue, (Bauman Verlag, 2005); and "What is Dada and What Does it Want in Cologne?" in *Dada: Zurich, Berlin, Hannover, Cologne, New York, Paris,* edited by Leah Dickerman (New York: Distributed Art Publishers, 2005).

Pierre Laszlo is a French science writer and Professor of Chemistry emeritus at the University of Liège (Belgium) as well as the École polytechnique (Palaiseau, France), with earlier positions at Princeton University and the Université d'Orsay and visiting professorships at the Universities of Connecticut, Kansas, California (Berkeley), Chicago, Colorado, Johns Hopkins, Lausanne, Hamburg, Toulouse and Cornell. He has written a dozen books to communicate chemical science to the general public, for which he received in 1999 the Maurice Pérouse Prize from the Fondation de France and in 2004 the Paul Doistau-Blutet Prize from the French Academy of Sciences. His latest books are *Le Phénix et la salamandre* (Le Pommier, Paris, 2004), *NO*, a pedagogic wordplay written jointly with Carl Djerassi (Deutscher Theaterverlag, Weinheim, 2003), *Qu'est-ce que l'alchimie?* (Paris: Hachette Littératures-Pluriel, 2003), *Les odeurs nous parlent-elles?* (Paris: Le Pommier, 2003), *L'architecture du vivant* (Paris: Flammarion, 2002), *Pourquoi la mer est-elle bleue?* and *Peut-on boire l'eau du robinet?* (Paris: Le Pommier, 2002), *Salt: Grain of Life* (New York: HarperCollins, 2002). Laszlo and his wife, the graphic artist Valerie Annette Jann, live in Sénergues, France and in Pinehurst, North Carolina, USA.

Nuala Lordan, see **Mary Wilson**

Ivor MacCarthy is a Senior Lecturer at the Department of Geology at University College Cork, Ireland. His research interests are concerned with the reconstruction of past environments through studies of ancient sediments. His work is focused on Devonian-Carboniferous sedimentary rocks and Pleistocene fluvio-glacial and marine sediments in Ireland. This work has resulted in the production of a number of geological maps, which depict the geological structure and composition of parts of southern Ireland. Some of this work has been carried out in conjunction with the Geological Survey of Ireland. While the maps are important data sources, they also interpret the geological structure and environmental aspects of the rock record.

Brendan McElroy is a lecturer in the Department of Economics, University College Cork. He got his PhD from University of Edinburgh in health economics. His recent publications include Virginia Wiseman, Brendan McElroy, Lesong Conteh et al., "Malaria Prevention in The Gambia: Patterns of Expenditure and Determinants of Demand at the Household Level," *Tropical Medicine and International Health* 11 (2006): 419-31; and Ann Kirby and Brendan McElroy, "Does Attendance Affect Grade? An Analysis of First Year Economics Students in Ireland," *Economic and Social Review* 34 no 3 (2003): 311–26.

Jim McGrath studies at the Department of Civil and Environmental Engineering at University College Cork where he is pursuing a PhD in the area of "Advanced Signal and Image Processing Techniques for Automated Mapping" under the joint supervision of J. Philip O'Kane and Richard C. Kavanagh. He is a graduate of the Department of Electrical and Electronic Engineering. (j.k.mcgrath@student.ucc.ie)

Stephen Mc Grath works with Douwe van Sinderen at the Department of Microbiology at University College Cork. His research focuses on the molecular biology of bacteriophages and his publications include "Anatomy of a bacteriophage tail" *Journal of Bacteriology* 188, pp. 3972-3982; and "Identification and Characterization of Phage-Resistance Genes in Temperate Lactococcal bacteriophages," *Molecular Microbiology* 43, pp. 509-20.

Paul McSweeney is Senior Lecturer in the Department of Food and Nutritional Sciences at University College Cork, Ireland. and has a BSc in Food Science and Technology and a PhD in Food Chemistry from the same university. The overall theme of his research is dairy biochemistry with particular reference to factors affecting cheese flavour. He is co-author or co-editor of 6 books and about 150 research papers and reviews. He was awarded the Marschall Danisco International Dairy Science Award in 2004.

Pat Meere is a lecturer in the Department of Geology at University College Cork, Ireland. His recent publications include: Meere and Kevin Mulchrone, "Timing of Deformation within Old Red Sandstone Lithologies from the Dingle Peninsula, SW Ireland," *Journal of the Geological Society* 163: 461-469; Meere, K.R. Choudhury, and Kevin Mulchrone, *Journal of Structural Geology* 28 no. 3: 363-375; and Meere, D. Quinn, and J.A. Wartho, "A Chronology of Foreland Deformation: Ultra-Violet Laser Ar^{40}/Ar^{39} Dating of Syn/late-Orogenic Intrusions from the Variscides of Southwest Ireland," *Journal of Structural Geology* 27 no. 8: 1413-1425.

Kieran Mulchrone works at the Department of Applied Mathematics at University College, Cork where he teaches modeling and numerical computing. His research is at the interface of structural geology and applied mathematics and is concerned with understanding the behavior of rocks during deformation. He has published over 20 scientific papers in the *Journal of Structural Geology, Tectonophysics*, and *Computers and Geosciences* (k.mulchrone@ucc.ie).

Caitríona Ó Dochartaigh works at the Department of Early and Medieval Irish, University College Cork. Her publications include "Questions of Orality, Performance and Transmission in Relation to Early Irish Prayer," *in Festgabe für Hildegard L.C. Tristram zum sechzigsten Gebürtstag,* edited by G. Hemprich et al. (Freiburg, 2001), 215-22; "Language and Identity in Early Medieval Ireland," *Études Irlandaises* 27 no. 2 (2002), 119-31; "Goethe's Translation from the Gaelic Ossian," in *The Reception of Ossian, European Critical Traditions: The Recep-*

tion of British Authors in Europe, edited H. Gaskill, (London, 2004), 156-75. (Dept of Early and Medieval Irish, UCC, Cork)

Nollaig Parfrey is professor of Pathology and consultant histopathologist at University College Cork and Cork University Hospital, Ireland. A medical graduate of University College Cork, his postgraduate training was at Johns Hopkins Hospital, USA and at McGill University, Canada. His research interests are in human molecular genetics, primarily in mapping and identifying human disease genes.

Marc Shorten works and studies at the Department of Zoology, Ecology and Plant Science at University College, Cork. His publications include Dorothy Cross, Tom Cross, and Marc Shorten, "Medusae," in *Experiment: Conversations in Art and Science,* edited by B. Arends and D. Thackara (London: The Wellcome Trust, 2003), 16-61; and Shorten, John Davenport, J.E. Seymour, M. Cross, T.J. Carrette, G. Woodward, and Tom Cross, "Kinematic analysis of Swimming in Australian Box Jellyfish, *Chiropsalmus sp* and *Chironex fleckeri* (Cubozoa, Cnidaria: Chirodropidae)," Journal of Zoology (London) 267 no. 4 (2005): 371-380.

Christina Spiesel is an artist and writer who is an Adjunct Professor of Law at both Quinnipiac University School of Law and New York Law School, and a Senior Research Scholar at the Yale Law School. Spiesel has been exhibiting her art since 1972. Her published writing includes: "A *Las Meniñas* for the Law," *in Images in Law* (Hampshire, UK, 2006); "Law in the Digital Age: How Visual Communication Technologies are Transforming the Practice, Theory, and Teaching of Law" (with Richard Sherwin and Neal Feigenson), Boston *University Journal of Science and Technology Law*, 2006; and "Law in the Age of Images" (also with Sherwin and Feigenson), in *Contemporary Issues of the Semiotics of Law* (London, 2005). Publication on arts issues include "Female Trouble" *in Trickster and Duality: The Dance of Differentiation,* edited by C.W. Spinks. A digital video, *Dream*, can be seen at www.poppingpixels.org. She was a contributor to SIGGRAPH 2006.

Bernadette Sweeney lectures in Drama and Theatre Studies at University College Cork. She directed theatre productions including Euripides's "Helen" (2004), a devised piece "wordmadeflesh" (2004), and a collaboration with half/angel dance theatre company on "The White Quadrangle" (2005). Her published articles and chapters include "*wordmadeflesh*: Writing the Body in Irish Theatre," in *Modern Drama,* edited by Brian Singleton and Karen Fricker (Toronto: University of Toronto Press, 2004); a biographical entry on Tom Mac Intyre *in Dictionary of Literary Biography 245: British and Irish Dramatists since WWII,* *Third Series,* edited by John Bull (Bruccoli Clark Layman, Inc., 2001); and "Form and Comedy in Contemporary Irish Theatre," in *The Power of Laughter,* edited by Eric Weitz (Dublin: Carysfort Press, 2004). She is developing a project on Irish Live Art with her colleague Franc Chamberlain. (b.sweeney@ucc.ie)

Andy Wheeler is a College Lecturer and Earth Science Degree Co-ordinator at the Department of Geology, University College Cork, Ireland. He has published extensively in national and international scientific journals and books on aspects of marine geology, from the sedimentary signature of storms and the environmental controls on shipwreck preservations, to the functioning of deep-water coral reefs. Selected recent publications can be found at www.ucc.ie/academic/geology/people/staff/ajw.html. (a.wheeler@ucc.ie)

Darius Whelan is a lecturer at the Faculty of Law, University College Cork, where he teaches Employment Law, Internet Regulation and International Trade Law. His publications and papers have covered topics such as criminal insanity law, mental health tribunals, use of the internet by lawyers and freedom of information law. He also runs the Irish Law site (www.irishlaw.org) and Irish Law discussion list. (d.whelan@ucc.ie)

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Mary Wilson, **Nuala Lordan** and **Deirdre Quirke** are all members of the Department of Applied Social Studies at University College Cork. Their joint publications include "When Words Are Not Enough: 'Facilitating angels in the funzone!'" in *Social Work with Groups,* edited by Carol Kuechler (New York, 2005); "Funzone: Using Groupwork for Teaching and learning," in *Groupwork*, edited by Mark Doel (London 2004), 9-29; "Family, Community, Church, and State: Natural Parents Talking about Adoption in Ireland," *British Journal of Social Work* 34 (2004): 621-48; "Maskmaking and Social Groupwork," in *Social Work with Groups*, edited by Carol Cohen (New York, 2003); "Breaking the Mold: Maskmaking as in Inclusive Educational Tool," in *Life's Rich Pattern: Cultural Diversity and the Education of Adults,* edited by David Jones and Gerald Normie (Glasgow 2002), 152-67.

Anna Zenkova, PhD, is working for a postdoctoral degree at the Institute of Philosophy and Law of the Urals Division of the Russian Academy of Sciences, Yekaterinburg, Russia. Her publications include "Visual Metaphor in Social and Political Discourse: Methodological Aspects," "Meaning Construction Mechanisms in Western and Arabic Cultures," "Death of the Animated Cartoon Character," "Visual Studies as Integral Part of Social and Humanitarian Knowledge," "Critique of Ocularcentrism in Modern Western Philosophy," and "The Construction Problem of New Ontology of Vision in Maurice Merleau-Ponty's Philosophy" (all in Russian). (azenkova@gmail.com)

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