Monthly Meeting
2012 Richards Medal Award Meeting at Harvard Richards Award to Professor Tobin Jay Marks

Summer Scholar Report
Observing and Controlling Molecular Rotors and Motors at the Atomic Scale - Allister F. McGuire and E. Charles H. Sykes, Tufts University

Book Review
Envisioning Information by Edward R. Tufte
Review by Jackie O’Neil

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Department of Chemistry, Tufts University, Medford, MA

2012 NESACS Candidates for Election

Cover: A Plastic Solar Cell converts sunlight into photo-electrons and holes.
Image courtesy of Richards Medal Award winner Tobin Jay Marks.

Deadlines:
May 2012 Issue: March 15, 2012
Summer 2012 Issue: June 15, 2012

The Nucleus is published monthly, except June and August, by the Northeastern Section of the American Chemical Society, Inc. Forms close for advertising on the 1st of the month of the preceding issue. Text must be received by the editor six weeks before the date of issue.
The Art of Quantitative Scientific Graphics

Visual representations of data are fundamental pillars of communicating scientific information. The thoughtful and careful visualization of data and trends can have a powerful effect when appropriately used. Some of the greatest visual representations were compiled over a hundred years ago and continue to be efficacious at communicating information rapidly and without confusion. From the elementary periodic table to the more complex table of nuclides, these powerful depictions provide shining examples of a way to quickly and unambiguously convey otherwise complicated information.

In the world of default tables and charts provided by PowerPoint and Excel, paired with tight timelines in both the academic and industrial sectors, it is all too often that quantitative data become muddled in a series of visually confusing tables or buried among ineffective graphics. As a researcher who is responsible for gathering, analyzing and communicating quantitative data, I continually try to improve my methods of creating more effective visual aids. In my quest to do so, I came across a book “Envisioning Information” authored by Edward R. Tuft, a celebrated statistician who is noted for his work on informational graphics.1

Tuft impressively describes effective systems that many scientists use frequently, such as small multiples, layering, and micro/macro readings. It was intriguing to see the explanation of how these types of visual comparisons guide our brains to observe patterns and draw conclusions based on creatively arranged visuals. But just as one can create a powerful graphic of complex quantitative data, there are many things that can disrupt the flow of information and render even simplistic data sets confusing to the audience. Developing an understanding of how these systems function allows the researcher to consider these ideas when analyzing and communicating complex data.

Today’s scientific achievements are often described by multi-variable systems that basic scatter plots, bar graphs and/or histograms struggle to represent. Only with a creative and thoughtful approach can one begin to honor the beauty of the informational systems they portray. One of the most helpful themes for me was the importance of emphasizing the quantitative information itself while reducing the clutter that is startlingly accumulated in the act of organizing information. The third chapter highlights how combining two visuals can sometimes add a layer of information, referred to the

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Book Review


Reviewed by Jackie O’Neil

The Art of Quantitative Scientific Graphics

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continued on page 13
Abstract

Plastic Solar Cells with Engineered Interfaces

The ability to fabricate molecularly tailored interfaces with nanoscale precision can selectively modulate charge transport and molecular assembly at hard matter-soft matter interfaces and can facilitate transport of the “correct charges” while blocking transport of the “incorrect charges.” This interfacial tailoring can also control carrier-trapping defect densities at interfaces and stabilize them with respect to physical/thermal decohesion. In this lecture, challenges and opportunities are illustrated for three specific and related areas of research: 1) controlling charge transport across hard matter-soft matter interfaces in electroluminescent devices, 2) controlling charge transport across hard matter-soft matter interfaces in organic photovoltaic cells, 3) controlling charge transport by active layer organization at electrodes. It will be seen that rational interface engineering along with improved bulk-heterojunction polymer structures affords high solar power conversion efficiencies along with greater cell durability.

References:
1. Lou, S.J.; Szarko, J.M.; Xu, T.; Yu, L.; Marks, T.J.; Chen, L.X., Additive Effects on Active Layer Solu-

Biography

Tobin Marks is Vladimir N. Ipatieff Professor of Chemistry and Professor of Materials Science and Engineering at Northwestern University. He received a B.S. degree in Chemistry from the University of Maryland (1966) and Ph.D. from MIT (1971) in Inorganic Chemistry. His research interests include transition metal and f-element organometallic chemistry; catalysis; vibrational spectroscopy; nuclear magnetic resonance; synthetic facsimiles of metalloprotein active sites; carcerinostatic metal complexes; solid state chemistry and low-dimensional molecular metals; nonlinear optical materials; polymer chemistry; tetrahydroborate coordination chemistry; macrocycle coordination chemistry; laser-induced chemistry and isotope separation; molecular electro-optics; metal-organic chemical vapor deposition; polymerization catalysis; printed flexible electronics; solar energy; and transparent conductors.

Marks has received American Chemical Society Awards in Polymeric Materials, 1983; Organometallic
**Announcements:**

**The Norris-Richards Undergraduate Summer Research Scholarships**

The Northeastern Section of the American Chemical Society established the James Flack Norris and Theodore William Richards Undergraduate Summer Scholarships to honor the memories of Professors Norris and Richards by promoting research interactions between undergraduate students and faculty.

Research awards of $3500 will be given for the Summer of 2012. The student stipend is $3000 for a minimum commitment of ten weeks of full-time research work. The remaining $500 of the award can be spent on supplies, travel, and other items relevant to the student project.

Institutions whose student/faculty team receives a Norris/Richards Undergraduate Summer Research Scholarship are expected to contribute toward the support of the faculty members and to waive any student fees for summer research. Academic credit may be granted to the students at the discretion of the institutions.

Award winners are required to submit a report (5-7 double-spaced pages including figures, tables, and bibliography) of their summer projects to the NESACS Education Committee by October 26, 2012 for publication in The Nucleus. They are also required to participate in the Northeast Student Chemistry Research Conference (NSCRC) in April 2013.

Applications will be accepted from student/faculty teams at colleges and universities within the Northeastern Section. The undergraduate student must be a chemistry, biochemistry, chemical engineering, or molecular biology major in good standing, and have completed at least two full years of college-level chemistry by Summer 2012.

Completed applications are to be submitted, no later than March 30, 2012, to the Chair of the Selection Committee: Professor Edwin Jahngen, Department of Chemistry, Olney 520 University of Massachusetts Lowell 1 University Avenue Lowell, MA 01854-5047

**The 2012 Theodore William Richards Award for Excellence in Teaching Secondary School Chemistry**

The Richards Award is the most prestigious award for high school chemistry teaching the Northeastern Section of the American Chemical Society offers in recognition of outstanding, innovative, and inspired teaching at the secondary level. It is intended to honor a teacher in the Northeastern Section who, through innovation and dedication, has inspired potential chemists, has communicated chemistry to non-chemists, or has influenced other teachers of chemistry.

The criteria for excellence correspond broadly to the effectiveness with which the teacher conveys chemistry, the innovative techniques used to help students comprehend chemical concepts, his/her interaction with students, both academic and extra-curricular, and the influence the teacher has had on other teachers for promoting new approaches to teaching and learning.

The selected teacher will be officially honored and will receive both a $1,500 prize and a Certificate of Recognition at the NESACS High School Night ceremony in May 2012.

A complete description of the award, the nomination criteria, and nomination forms can be obtained from the NESACS website at: <http://www.nesacs.org/awards_richards.html>

Nominations are due no later than April 15, 2012 to the Richards Award Committee, attn: Steve Lantos, steve_lantos@brookline.k12.ma.us (or via US Mail: Steve Lantos, Sci. Dept. Brookline HS, 115 Greenough St, Brookline MA 02445)

**Recommendations Wanted For NESACS 2012 ACS Fellows Nominations**

The ACS Fellows Program was created by the ACS Board of Directors in December 2008 “to recognize members of ACS for outstanding achievements in and contributions to Science, the Profession, and the Society (see portal.acs.org/acsfellows for details).

The Northeastern Section of ACS, NESACS, solicits your recommendations for the names of members who should be nominated for ACS Fellows by the local section. Eligibility for this honor is given on the ACS website. If your recommended nominee is selected, you will be asked to prepare a nomination package. If your recommendation is not selected, you may individually nominate that person. The ACS website also gives the instructions for preparing the nomination package.

The window for submitting nominations for 2012 ACS Fellows will open towards the end of the first quarter of 2012. Please submit the name along with a brief paragraph as to why you are making the recommendation to Anna Singer at secretaty@nesacs.org promptly but no later than March 10.

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The Northeastern Section of the American Chemical Society (ACS) is sponsoring an illustrated poem contest for students in Kindergarten - 12th grade.

Contest Deadline: Entries must be received by March 30, 2012.

Prizes: The winning entry for each grade range will receive a $25.00 gift certificate to www.amazon.com, as well as an Earth Day t-shirt. Teachers of the winning students will receive a $25.00 gift certificate to www.teachersource.com

Contact: Submit entries to: Christine Jaworek-Lopes
        Emmanuel College
        400 The Fenway
        Boston, MA 02115

Poems must include an entry form, which is available at www.nesacs.org.

Winners of the Northeastern Section illustrated poem contest will advance to the ACS National Illustrated Poem Contest!

Write and illustrate a poem using the CCED theme, “Rethinking Recycling—It’s Easy to Be Green!” Your poem must be no more than 40 words, and in the following styles to be considered:

- Haiku
- Limerick
- Ode
- ABC Poem
- Free Verse
- End Rhyme
- Blank Verse

Possible topics related to recycling and chemistry include:
- Recyclable materials (e.g. aluminum, glass, paper, plastic) and the related chemistry
- Green chemistry and sustainability
- Biodegradable materials
- Reduction of greenhouse gases, pollution, and waste
- Any other relevant topics

Entries will be judged based upon:
- Relevance and incorporation of the theme
- Word choice and imagery
- Colorful artwork
- Adherence to poem style
- Originality and creativity
- Overall presentation

Contest Rules:
- Poems must conform to a particular style. No poem may be longer than 40 words.
- The topic of the poem and the illustration must be related to the CCED 2012 theme, “Rethinking Recycling—It’s Easy to Be Green.”
- All entries must be original works without aid from others.
- Each poem must be submitted and illustrated on an unlined sheet of paper (of any type) not larger than 11” x 14”. The illustration must be created by hand using crayons, watercolors, other types of paint, colored pencils or markers. The text of the poem should be easy to read and may be printed with a computer, before the hand-drawn illustration is added, or the poem may be written on lined paper which is cut out and pasted onto the unlined paper with the illustration.
- Only one entry per student will be accepted.
- All entries must include an entry form.
- All illustrated poems and/or digital representations of the poems become the property of the American Chemical Society.
- Acceptance of prizes constitutes consent to use winners’ names, photographs and entries for editorial, advertising and publicity purposes.
Summer Scholar Report
Observing and Controlling Molecular Rotors and Motors at the Atomic Scale
Allister F. McGuire and E. Charles. H. Sykes, Department of Chemistry, Tufts, University, Medford, MA

Introduction. Sources of microscopic biological motion include flagellar motors and kinesin and myosin on actin filaments which are driven by chemical phenomena such as proton and sodium gradients, or conformational changes due to ATP binding. Lately, some studies have elucidated the mechanisms for such motion in biological systems. In a very different approach simple synthetic systems have been devised in order to study chemical and photon-driven molecular motion in an understandable manner. In recent work, using scanning tunneling microscopy (STM), we demonstrated a synthetic, electrically driven single-molecule motor with up to 5% directionalidad. This was accomplished by using butyl methyl sulfide (BMS) on Cu(111) and a chiral tungsten STM electrode. The BMS molecule adsorbs to the surface via one of two lone pairs of the central sulfur atom and rotates about this sulfur-copper bond, which we observe using ultra high vacuum low-temperature STM (UHV LT-STM). Because the speed of rotation (on the order of 50 Hz) is faster than the imaging capabilities of the instrument (~0.01 Hz), the molecule appears as six lobes as dictated by the meta-stable residence of the molecule in six equivalent energetic minima on the Cu(111) surface. Additionally, although the molecule is achiral in the gas phase, adsorption to the surface generates chirality in the system, causing the molecule’s lobes to image asymmetrically, like a so-called “pinwheel.” We have postulated that this chirality imparts a bias critical to a driving mechanism informed by the model of a flashing temperature ratchet and vibrational excitation dynamics.

To extend this proof of principle study, we are exploring rotor ligands with more complex functionality or geometry than those of linear aliphatic ligands—a process of so-called “chemical tuning.” If manufactured, a precise arrangement of motors on a metal surface, such that the rotation of one molecule can propagate throughout the array, will lead to pathways for unobtrusive sensing, fluid pumps and other novel molecular electronics. The most obvious place to begin seeking this sort of intermolecular cooperation is in dipole-dipole interactions. Three functionally distinct systems are herein described on single-crystal metal surfaces. In the first, the presence of a phenyl group lends both dipolar character and opportunity for π–π interactions. In the second, a hydroxide group has potential to retard rotation due to oxygen lone-pairs interacting with the metal surface and yield stronger rotor-rotor interactions. Finally, in the third system, chiral branched functionality could, by the current mechanism, lead to heightened anisotropic directionality and potentially the formation of enantiopure molecular motor arrays.

Experimental. All data have been acquired with an Omicron UHV LT-STM at a temperature of either 5 or 80 K. Pre-deposition, high-energy Ar ion sputtering and annealing cycles were performed to ensure the cleanliness of the Cu and Au single crystals. All chemicals were purchased from Sigma-Aldrich, Inc. at ≥ 98% purity and further purified in situ by freeze-pump-thaw cycles. In all cases, an etched W metal electrode (“tip”) was used to probe the system.

Results and Discussion. The first molecule studied, phenyl methyl sulfide (thioanisole), has a dipole moment of 1.38 D (Debye). Deposited on both Cu(111) and Au(111) at low coverage (~0.17 mono layer), the molecule is expected to exhibit a six-lobed pinwheel-like configuration; however, the imaged molecules do not display any obvious asymmetry and rarely the expected six lobes—more regularly, four lobes resolve (Figure 1). The effect could be attributed to the fact that a transition from the molecule’s naturally planar structure to a parallel ring-to-metal structure requires surmounting an energy barrier greater than the energy gained by electron donation from π molecular orbitals to the surface. Note that the molecule in such a perpendicular orientation interacts less strongly with the metal surface through radial phenyl hydrogen atoms than it does through the hybridized carbon atoms. Additionally, the steric strain generated by a thioanisole ring oriented perpendicular to the metal surface is highly unfavorable. This hypothesis is further substantiated at increased surface coverage where, despite displaying the expected intermolecular ordering, rows terminate in an unconventionally smooth, rounded pattern. This directly suggests that the phenyl rings stack roughly perpendicular to the surface, in order to maximize π–π interactions. Conversely, this structure is not found in small thioethers with aliphatic ligands, which instead terminate abruptly. Although high-coverage ordering of the thioanisole system is intriguing, the absence of obvious 2D chirality renders the system untenable in the short term for quantifying rotor dynamics in search of anisotropic directionality. Future work is needed to ascertain the binding site of thioanisole and, in doing so, give reason for the rare manifestation of chirality.

In an attempt to elucidate the utility of a strong dipole moment in coupling rotors, 3-(methylthio)propanol was studied. This is a lesser studied molecule but fits in the character of molecules to be studied for motor-like properties as it has limited functionality and dipolar character. A thorough search of the literature did not yield a value for the dipole moment for 3-(methylthio)propanol, yet it is similar, with respect to the quantity in question, to 1-propanol. The assumption of similar dipole moments can be justified by the negligible difference in electronegativity between sulfur and carbon, such that this substitution should not engender a difference in electron density distribution across the molecule. Therefore, as a reference point, 1-propanol has a gas phase dipole moment of 1.65 D.
Exposure of the Cu(111) and Au(111) crystals to $10^{-9}$ mbar of 3-(methylthio)propanol for 30 seconds gives a partial monolayer (0.09 ML). At such a coverage, 3-(methylthio)propanol images as a six-lobed rotor species on both Cu and Au (Figure 1). Although some asymmetry in the lobes is often evident, it is inconsistent and does not resemble a pinwheel structure; therefore, chirality has not been assigned. Thus, again, the lack of obvious 2D chirality hindered the use of a molecule for rotational dynamics studies. The molecular coverage was increased to 0.18 ML and the sample was annealed to roughly 34 K, causing the molecules to aggregate into small H-bonded motifs composed of 4, 5 and 6 molecules (Figure 2). Further investigation of 3-(methylthio)propanol at high coverage would reveal whether these networks truly form a 2D inverse micelle with hydrophilic hydroxide groups that drive nucleation and radial non-polar tails. Such a structure would be of use in nanoscale surface functionalization.

We subsequently proceeded to tune the rotors in yet another way by studying the branched aliphatic butyl sec-butyl sulfide (BsBS). A structural isomer of dibutyl sulfide and a chiral molecule in the gas phase, BsBS has a geometric profile yet uninvestigated under our dynamics framework. At sub-monolayer coverage on Au, 2D chirality manifests itself as the pinwheel shape (Figure 1). Two ambiguities present themselves in these images: first is the bright center of the rotors. It is reasonable to posit that this corresponds with the methyl group of the sec-butyl chain projecting towards the sulfur atom and, being closer to the STM tip, generating a brighter image. The second ambiguity lies in the absolute chirality of these rotors. As the molecule is chiral in the gas phase and, upon adsorption through a dative bond, the sulfur atom takes on chirality, theory predicts the presence of two BsBS enantiomers and two BsBS diastereomers. Because the dosed gas is a racemate, it is impossible to determine the absolute chirality of the observed molecules without further control of the system. To this end, we have requested the synthesis of the enantiopure BsBS by the Kumar group of Tufts University.

Although the absolute conformation of the imaged

Figure 1. Schematic representation of the interrogated molecules adsorbed on an ambiguous (111) surface. A1 and A2 are butyl sec-butyl sulfide molecules of different handedness at the sec-butyl α-carbon. B is 3-(methylthio)propanol and C is thioanisole. Arrows indicate axes of rotation.

Figure 2. (A) 3-(methylthio)propanol at ~17.5% coverage on Cu(111) after anneal to 120 K. Scanning conditions: $T = 5 \text{ K}, I_t = 40 \text{ pA}, V_s = 100 \text{ mV}$. (B) Thioanisole at ~26.9% coverage on reconstructed Au(111). Preferred binding occurs on fcc domains. Scanning conditions: $T = 80 \text{ K}, I_t = 15 \text{ pA}, V_s = 500 \text{ mV}$.
adsorbates has yet to be elucidated, previous work suggests some paradigms and relative assignments are still valid (Figure 3). It is clear, after all, that some part of the conformation is of opposite stereochemistry. A critical quantification in investigating the dynamics of chiral single-molecule rotors is how resiliently they maintain a given chirality. There is some probability in all such thioether systems that chirality could invert, involving a full dissociation of the sulfur-metal bond and subsequent bonding through the alternate lone-pair. While BsBS is relatively static at non-perturbative scanning conditions, the molecules experience ~375 meV when electronic coupling to a C-H stretch induces rotation—energy which could redistribute into chiral inversion.4,12 Figure 3 displays an experiment wherein a group of BsBS molecules were distributed across the Cu surface and, over the course of four consecutive images (~120 seconds/image), the scanning voltage was ramped from 300 mV in 3A to 400 mV in 3B and 3C, and back to non-perturbative 300 mV scanning conditions in 3D. The rotors here do not display lobes when rotating, but the streakiness of the images indicates that the rotational speed is faster than the timescale of imaging (i.e. this is an alternative version of the pinwheel motif). It is important to note that although the vibrationally excited molecules rotate and migrate across the Cu surface in C, when scanned in D, they maintain their chirality. The experiment described above suggests that the energetic barrier to chirality inversion is greater than that to rotation or migration (or that the probability of coupling to chirality inversion is very small) —either way a positive result when interrogating the molecules for motor applications. This, as well as preferential binding between diastereomers, could be further substantiated by density functional theory (DFT) calculations; however, the lengths of the butyl and sec-butylligands demand a slab of enough Cu atoms that the calculations would be impractically time-consuming. Therefore, we have requested that the Sholl group at Georgia Institute of Technology explore a smaller analogue, methyl sec-butyl sulfide.

During the course of experiments with BsBS, perturbative currents of 20 nA (~100x normal scanning current for this system) were used to drag individual molecules across the crystal surfaces to either form or disrupt molecular assemblies (Figure 4). Beyond the intrigue of manipulating single molecules, the practice of doing so indicates a labile sulfur-metal bond, amenable to chemical modification.

High-coverage data was also taken for BsBS (Figure 5A) wherein the intermolecular disorder shown for the BsBS system contrasts sharply with the order of its linear structural isomer, dibutyl sulfide (Figure 5B). The disorder could be due to branching in the sec-butyl chain or due to the presence of multiple conformers on the surface. The strongest step towards elucidating this difference will be experimenting with enantiopure BsBS.

Conclusions. The results discussed suggest that studying the rotational dynamics of more functionally complex thioether molecules (in comparison with butyl methyl sulfide) introduces new intricacies in the overall system, such that certain molecules do not fit into the current framework which correlates chirality to directed motion. Due to our confidence in the versatility of our framework, we proceed

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**Summer Scholar**

*continued from page 9*

![Figure 3](image3.png)

**Figure 3.** Sequential STM images taken on Cu(111) depicting the onset of rotation (indicated by streaky imaging) in chiral BsBS adsorbates with increase of bias voltage above the C-H resonant, rotation-inducing energy of 360 meV. (A) displays four single molecules of identifiable chirality. After rotation (B,C) and migration (C), the rotors cease to rotate with sub-resonance voltage and chirality is again identifiable. Imaging conditions: T = 5 K, It = 200 pA.

![Figure 4](image4.png)

**Figure 4.** Using perturbative current (20 nA), one BsBS molecule is dragged with the W STM tip towards another, inducing the dimer seen at right. Imaging conditions: T = 5 K, It = 400 pA, Vs = 300 mV.

![Figure 5](image5.png)

**Figure 5.** At left, BsBS and at right, dibutyl sulfide at high coverage ~0.7 ML on Au(111). Imaging conditions— T = 80 K; BsBS: It = 50 pA, Vs = 500 mV; DBS: It = 30 pA, Vs = -30 mV.

High-coverage data was also taken for BsBS (Figure 5A) wherein the intermolecular disorder shown for the BsBS system contrasts sharply with the order of its linear structural isomer, dibutyl sulfide (Figure 5B). The disorder could be due to branching in the sec-butyll chain or due to the presence of multiple conformers on the surface. The strongest step towards elucidating this difference will be experimenting with enantiopure BsBS.

**Conclusions.** The results discussed suggest that studying the rotational dynamics of more functionally complex thioether molecules (in comparison with butyl methyl sulfide) introduces new intricacies in the overall system, such that certain molecules do not fit into the current framework which correlates chirality to directed motion. Due to our confidence in the versatility of our framework, we proceed...
with chemical tuning until appropriate molecules are found. BsBS is one such molecule and will garner further study upon the generation of the enantiopure compound and DFT results for its analogue. Experiments using the enantiopure molecule will yield current vs. time curves correlated to absolute chirality—a correlation necessary to generate precise rotational dynamics conclusions that will augment the current body of knowledge concerning single-molecule motors. Evidence of only two of four possible conformers indicates that there may be a preferential binding conformation due to chirality at the sec-butyl α-carbon, which would lend itself to studies as a vector for enantioselective synthesis and surface patterning. These studies will proceed as soon as the necessary chemical and theoretical resources are made available.

Acknowledgements. A.F.M. would like to thank the NESACS for a James Flack Norris/Theodore Henry Richards Summer Research Scholarship. A. F. M. is also grateful to Colin Murphy, April Jewell and Emily Lewis for help with running experiments and engaging in fruitful discussions. The NSF is also gratefully acknowledged for providing funding to travel to the fall 2011 meeting of the ACS to present these results.

References:

Marks has published over 1035 papers and holds 206 US patents.

Summer Scholar continued from page 11


CAREER DEVELOPMENT

Being an active participant in NESACS activities will enable you to network with major institutions and corporations in our area and can open up new career opportunities.

The NESACS Board of Publications, which is responsible for both the Nucleus newsletter and the NESACS website, is looking to increase its activities in this arena.

We would like to expand our capabilities for keeping our membership informed on what is happening in our field and how to adapt to changing times and new technologies.

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Contact – Vivian Walworth
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The Nucleus March 2012 13

1+1=3 effect, an idea originally described by Josef Albers in 1969.2

Simple tricks, such as removing the visually-obstructive default thick black borders on figures and tables, and using transparent spacing between visuals that are intended for direct comparison, are discussed in this book, to give scientists and data collectors alike tools that can immediately help improve their own graphics. With its minimalistic text and emphasis of the subconscious visual experience for the audience, this book clearly demonstrates that a few simple key guidelines can have a lasting impact on the quality and effectiveness of how quantitative information is visually conveyed and ultimately understood by the audience.


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Mar 01
Prof. Louis Brus (Columbia)
Graphene: electron correlation and failure of the Born-Oppenheimer separation
Harvard, Pfizer Hall
5:00 pm

Mar 02
Bristol-Myers-Squibb Lecture in Organic Chemistry
Prof. Amir Hoveyda (Boston College) & Dr. Jaan Pesti (BMS)
MIT, 6-120
4:00 pm

Dr. Matthew Lockett (Harvard)
Univ. New Hampshire, Room N104 (L103)
11:10 am

Mar 05
Prof. Joanna Aizenberg (Harvard)
Brandeis Univ, Rosenstiel 118
4:00 pm

Mar 06
Prof. Ivan Aprahamian (Dartmouth College)
Hydrazone-Based Rotary Switches
Univ. New Hampshire, room N104(L103)
11:10 am

Mar 07
Prof. Gerard Parkin (Columbia University)
MIT, 6-120 4:15 pm

Mar 08
Prof. Marco Rolandi (Univ. Washington, Seattle)
Boston College, Merkert 130 4:00 PM
Dr. Charles E. Turick (Savannah River National Laboratory)
Univ. New Hampshire, Room N104 (L103)
11:10 am

Mar 09 & 10
Prof. Paul Knochel (Universität München)
Bristol-Myers Squibb Lecturer
Boston College, TBA Time: TBA

Mar 12
Prof. Ivan Aprahamian (Dartmouth Univ.)
Brandeis Univ, Rosenstiel 118 4:00 pm

Mar 13
Prof. Hubert Yin (Univ. of Colorado)
Boston College, Merkert 130 4:00 PM
Prof. David Vanden Bout (Univ. of Texas at Austin)
“Spectroscopy of Conjugated Polymer Aggregates: Building up Thin Films from Single Polymer Chains”
MIT, 6-120 4:30 pm

Mar 16
Dr. Hien Nguyen (University of Iowa)
“Catalytic Transformations of Imidates and Epoxides: Application to the Synthesis of 1,2-Cis-2-Aminosugars, Allylic Fluorides and Allylic Amines”
Northeastern Univ, 129 Hurtig Hall
12:00 pm

Mar 19
Prof. Daniel Raleigh (Stonybrook)
Brandeis Univ, Rosenstiel 118 4:00 pm

Mar 21
Prof. Wenbin Lin (Univ.North Carolina - Chapel Hill)
MIT, 6-120 4:15 pm

Mar. 22
Prof. Gerhard Hummer (National Institute of Health, Chemical Physics Lab)
MIT, 6-120 5:00 pm
Prof. Amber Hupp (Holy Cross)
Univ. New Hampshire, Room N104 (L103)
11:10 am

Mar 26
Prof. Joe Beckman (Oregon State Univ.)
Superoxide dismutase and ALS: Did free Radicals kill Lou Gehrig?
Brandeis Univ, Rosenstiel 118
4:00 pm

Mar 27
Prof. Norito Takenaka (Univ.Miami)
Boston College, Merkert 130 4:00 pm

Mar 28
Dr. Daniel Kirby (Harvard Art Museums)
“Cultural heritage, art conservation and analytical chemistry: the intersection of art and science”
Northeastern Univ, 129 Hurtig Hall 12:00 pm

Notices for The Nucleus Calendar of Seminars should be sent to:
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