

Heady Harmonocosms
The Honors College, Florida International University
IDH 3034,3035/4007,4008 Fall 2017/Spring 2018
Instructor: David A. Becker

Monday 4:00-6:50 PM
Email: beckerd@fiu.edu Phone: (305) 348-3736
Office: CP 318
Office Hours: Mondays from 2:30 PM to 3:30 PM and by appointment.

“Nature geometrizeeth and observeth order in all things”
-Sir Thomas Browne

Imagine taking twelve particular keys of a piano (the seven white keys and five black keys from a C such as Middle C to the note before the next higher C) and placing the name of each tone assigned to these twelve piano keys onto a fascinating and obscure twelve-faced three-dimensional object so that one tone appears on each of the twelve faces in a certain arrangement. Now imagine that, of the millions of possible arrangements, the certain arrangement put into place allows the chord sequences and even melodies of a huge number of popular rhythm and blues songs to be easily visualized by traveling in a continuous path that connects the quadrilateral faces of this mysterious gem-like object. And that's not all. New songs with appealing qualities can be composed with the device. How is this possible? Embark on a journey that bridges music with geometry, and that finds manifestations of mutuality between these areas and the realms of molecular biology and animal morphogenesis.

Course Requirements:

The course will be conducted as a seminar. Students are expected to come to class prepared and participate fully in the discussions. Assignments must be submitted on time. Attendance is mandatory and tardiness is unacceptable. All students must adhere to the Academic Integrity Policy of The Honors College and Florida International University.

Course Learning Outcomes:

At the end of this course, students will have acquired skills involving the use of geometry in the analysis and composition of music exhibiting Western harmony and will gain an appreciation for geometric principles with interdisciplinary applicability. The course fosters global learning by encouraging students to carefully contemplate the common biological patterning in all humans and to express their innate creativity in the context of the universal languages of music and geometry. The original musical composition prepared by each student enhances the student's appreciation of the Arts and may constitute a project worthy of addition to the student's Honors College Portfolio.

Assignments and Grading Structure:

Fall Semester: Midterm – 25% of final grade; Final Exam – 35% of final grade;
Dodecahedral Analysis of an approved composition by an artist of the student's choosing
– 40% of final grade.

Required Texts and Materials:

- David A. Becker, *Incarnations of the Blaring Bluesblinger: A Multimedia Mathmantra on Manifestations of Mutuality in Music, Molecules, and Morphogenesis*, San Diego, CA, University Readers, 2010, ISBN: (978-1-609279-55-4), 338 pages, \$109.00.
- Thomas Browne, *The Garden of Cyrus*, available on-line at the following URL: <http://penelope.uchicago.edu/gardenframes/gardenn.html>
- Istvan Hargittai, Magdolna Hargittai, *Symmetry: A Unifying Concept*, Bolinas, CA, Shelter Publications, Inc., 1994, ISBN-13: 978-0898155907, 222 pages, (new or used copies of this book are available for purchase for approximately twenty dollars from such on-line providers as amazon.com)
- Joscelyn Godwin, *The Revival of Speculative Music*, *The Musical Quarterly*, Vol. 68, No. 3 (Jul., 1982), pp. 373-389 (this article is available from the FIU library)
- Nenad Trinajstić, *The Magic of the Number Five*, *Croatica Chemica Acta*, Vol. 66, No. 1, pp. 227-254 (this article will be provided by the instructor)
- Felix Mann, David Bowsher, Jim Mumford, Sampson Lipton, John Miles, *Treatment of Intractable Pain By Acupuncture*, *The Lancet*, 1973, Vol. 302, pp. 57-60 (contains a discussion of the traditional anatomical roles of pertinent numbers in Chinese medicine)

Other materials assigned by the instructor (such as video clips, music, etc.) will be provided with their respective URL's.

CLASS SCHEDULE (Fall Semester)

The last 15-30 minutes of each lecture will be devoted to the construction of an original dodecahedral composition as a collective class effort.

Date	Topic
8/21	Overview, 3-D music?, Platonic Solids, Duals, Convex polyhedra, Kepler's 1619 rhombic dodecahedron from "Harmonice Mundi", Origami and a particular intonation of the rhombic dodecahedron (each student will construct an origami rhombic dodecahedron), Discussion of the chapter entitled "Cubes and Other Polyhedra" from the textbook "Symmetry: A Unifying Concept", A listen to some music from intonated rhombic dodecahedra.
8/28	Calculating distinct intonations of the rhombic dodecahedron, Other geometric entities described by the face centers of a rhombic dodecahedron, Polyhedra in nature, A discussion of Sir Thomas Browne's book "The Garden of Cyrus", Quincunxes.
9/11	Twelve quincunxes in a cube, Douthett and Steinbach's "Cube Dance", Chord theory, Tertian harmony, Triads, tetrads, and pentads, The predominant preclusion of tone clusters in tonal music, Jazz and pentads, Pascal's triangle and chord enumeration, Why a twelve-tone system?, Yin/Yang and the Circle of Fifths, 1,4,5 and the Circle of Fifths, Major/Minor and 1,4,5 triads in Euler's 1739 tonnetz, Euler and the birth of graph theory.
9/18	Crucial 1,4,5 pentadic relationships in a particularly intonated rhombic dodecahedron, Consonance and dissonance in balance, Fuller and polyhedral balance, Tonal seeding of the rhombic dodecahedron. Video of Leonard Bernstein discussing the importance of dissonance in a 1957 Omnibus telecast.

- 9/25 Schlegel diagrams, Cuboctahedral graphs, Seeding a cuboctahedral graph, Non-convex polyhedra, Neighboring and non-neighboring chords, Multiple chord qualities for a given polytonic set, Case Study: “The Long and Winding Road” by the Beatles.
- 10/2 Chord progressions that require cuboctahedral graph relatives such as the anticuboctahedral graph, The famous Kepler Conjecture concerns both the cuboctahedron and the anticuboctahedron, Duality of the anticuboctahedron/trapezo-rhombic dodecahedron, Classification of the anticuboctahedron as a Johnson Solid, Planar quartic graphs, Planar graphs and the sphere, Other planar quartic graphs on twelve vertices, The bluesblinger graph, Dodecahedra and Hugo Steinhaus.
- 10/9 A highly ordered jazz/blues intonation of the bluesblinger graph, Visualization of the bluesblinger dodecahedron, Steinitz’s Theorem, The convex bluesblinger dodecahedron (each student will construct an Origami bluesblinger dodecahedron), The bluesblinger dodecahedron’s notable bilateral symmetry, Non-convex versions of the bluesblinger dodecahedron, Non-manifold edges, Geometric analysis of the original music piece “Code of Blues”, The centered collinear tritone pair midpoints within the Schlegel representation of the bluesblinger code, Application of the bluesblinger code in the analysis of some popular songs in the blues and jazz genres. The twelve pentatonic sets of the bluesblinger code.
- 10/16 Midterm
(prior to the exam, students should, in writing, submit their chosen song for analysis in order to gain approval)
- 10/23 Further analysis of other dodecahedral compositions in a range of genres. Dodecahedral analysis of the Miles Davis classic “All Blues”.
- 10/30 Music and body plan in Godwin’s article “The Revival of Speculative Music”, Discussion of the first chapter entitled “Bilateral Symmetry” within the book “Symmetry: A Unifying Concept”, Cadherin proteins

and cell adhesion, The pentameric classic cadherin extracellular repeat domains, The thirteen type II classic cadherins in vertebrates, The role of cadherins in brain wiring, Recent work concerning type II cadherins and autism, Cadherin networks and the bluesblinger graph, Versions of the bluesblinger dodecahedron as generalized cephalic/brain scaffolds. The icosahedron in virology. Henry Gray's bluesblinger pharynx?

- 11/6 Animal skulls resembling the bluesblinger dodecahedron, Anatomical occurrence of the number twelve, Twelve cadherin superfamily members in a code for a brain subunit, Twelve homeobox genes expressed in the developing mammalian head, The strong biological link between bilateral symmetry and cephalization.
- 11/13 12 primary myelination zones in the developing brain (Flechsig), fields of the monkey auditory cortex, axial morphogenesis. Brain connectivity in the work of Olaf Sporns.
- 11/20 Students present and submit their dodecahedral song analyses.
- 11/27 Review session for final exam.
- 12/4 Final Exam

Spring Semester: Midterm – 25% of final grade; Final Exam – 35% of final grade; Composition of an original piece of tonal music with the dodecahedral methodology– 40% of final grade (the song must employ all twelve pentatonic sets)

The last 15-30 minutes of each lecture will be devoted to the construction of an original dodecahedral composition as a collective class effort.

- 1/8 The class, guided by the instructor, conducts research to examine whether salt/hydrogen bridges can offer insight into Shimoyama's cadherin network based upon cadherin amino acid sequences. The antiparallel binding hypothesis. Phylogenetic analysis of type II cadherins according to Van Roy.

- 1/22 A balance of autobiographical consonances and dissonances in the instructor's encountered pathways, A longstanding friendship with esteemed jazz guitarist Randy Bernsen, Discussions with jazz guitarist Pat Metheny concerning dodecahedral music, A listen to Coltrane's classic harmonic masterpiece "Giant Steps", Jazz guitarist Pat Martino's geometric analysis of "Giant Steps", Dodecahedral analysis of "Giant Steps".
- 1/29 Martino's "Giant Steps" analysis and a crucial graph of Kuratowski's Reduction Theorem, Pat Metheny's composition "(It's Just) Talk", Dodecahedral analysis of the head to Metheny's "(It's Just) Talk".
- 2/5 Tymoczko's admirable goal of mapping all chords with orbifolds from string theory, A present dearth of pentachord orbifold maps, Physicist's focus on string theory in 10-D and 11-D, Is there a hexatonic analog to the paradigmatic pentachord-based intonation of the rhombic dodecahedron?, Does the orbifold approach posit that cardinality five is special? Expanding pentatonic sets into heptatonic sets, Expansion of diatonic pentatonic sets, Expansion of non-diatonic sets, The context-dependence of tone set expansions.
- 2/12 Geometric analysis of the blues scale (the first half of this session involves students working independently on this 3-D analysis), 3-D geometric analysis of the major scale, The "chalice" graph via graph contraction, The chalice graph applied to James Taylor's composition "Your Smiling Face" (the class will listen to the piece).
- 2/19 A listen to Carlos Santana's and Tom Coster's "Europa", Analysis of "Europa" in three dimensions, "Europa's" nine tones on a halved Archimedean Solid, From Euler's 2-D tonnetz to the paradigmatic intonation of the 3-D rhombic dodecahedron, "Europa's" bass line and

the seven tones of a halved Circle of Fifths.

- 2/26 Midterm
- 3/5 Consonance and functional dissonance in overall balance, The twin dodecahedral progeny of the Circle of Fifths, Medial and lateral as a ramification of bilateral symmetry, A discussion of pertinent aspects of Chinese medicine as highlighted in the assigned 1973 article from the Lancet. A discussion of the assigned article “The Magic of the Number Five”, Pentagonal numbers, Fermions in particle physics, Wu Xing, Morphogenetic parallels of prominent tonal geometries. Amphids, tergites, and opisthosomas.
- 3/19 A musical idol from the instructor’s childhood (Jaco Pastorius), Randy Bernsen and Jaco Pastorius, Some famous music of Jaco Pastorius, Recordings featuring Bernsen and Pastorius, Pastorius and “The Sound of Music”
- 3/26 Cuboctahedral analysis of “The Sound of Music, Richard Rodgers and Harold Arlen, Chittenango and the yellow brick sidewalk, Harold Arlen’s Syracuse connections, Arlen’s recently discovered Connections to the instructor’s family, Connectivity, Cuboctahedral Analysis of “Over the Rainbow”, Epilogue
- 4/2 Student concert featuring their original dodecahedral compositions as well as the original class composition. Students submit their compositions and respective geometric analyses to the instructor
- 4/9 Concert with the Randy Bernsen Trio featuring a student composition selected by student vote.
- 4/16 Review Session
- 4/23 Final Exam

SUPPLEMENTARY READING

1. For a newly elucidated protein with cuboctahedral geometry, see: S.M. Stagg, C. Gurkam, D.M. Fowler, P. LaPointe, T.R. Foss, C.S. Potter, B. Carragher, W.E. Balch, "Structure of the Sec13/31 COPII coat cage", *Nature*, 2006, vol. 439, p. 234-238.
2. J. Douthett, P. Steinbach, "Parsimonious Graphs: A Study in Parsimony, Contextual Transformation, and Modes of Limited Transposition", *Journal of Music Theory*, 1998, vol. 42, p. 241-263.
3. H. W. Kroto, J. R. Heath, S.C. O'Brien, R.F. Curl, R.E. Smalley, "C₆₀: Buckminsterfullerene", *Nature*, 1985, vol. 318, p. 162-163.
4. J. Bennighof, "Set Class Aggregate Structuring, Graph Theory, and some Compositional Strategies", *Journal of Music Theory*, 1987, vol. 31, p. 51-98.
5. For a review of Euler's famous 1736 graph theory work, see: G.L. Alexanderson, "Euler and Konigsberg's bridges: a historical view", *Bulletin of the American Mathematical Society*, 2006, vol. 43, p.567-573.
6. N.W. Johnson, "Convex Solids with Regular Faces", *Canadian Journal of Mathematics*, 1966, vol. 18, p. 169-200.
7. a) M. Meringer, "Fast Generation of Regular Graphs and Construction of Cages", *Journal of Graph Theory*, 1999, vol. 30, p. 137-146. b) Markus Meringer's Regular Graphs website (www.mathe2.uni-bayreuth.de/markus/reggraphs.html)
8. D. Sipp, "Discovery and characterization of the cadherin superfamily of cell adhesion molecules. An interview with Masatoshi Takeichi.", *International Journal of Developmental Biology*, 2004, vol. 48, p. 387-396.
9. For a review of the cadherin superfamily, see: P. Hulpiau, F. Vanroy, "Molecular evolution of the cadherin superfamily", *The International Journal of Biochemistry and Cell Biology*, 2009, vol. 41, p. 349-369.
10. For a recounting of the seminal work on icosahedral virus structures, see: D.L.D. Caspar, "This Week's Citation Classic", *Current Contents*, 1984, vol. 27, p. 15. See also: D.L.D. Caspar, A. Klug, "Physical principles in the construction of regular viruses", *Cold Spring Harbor Symp.*, 1962, vol. 27, p. 1-24.

11. Y. Shimoyama, G. Tsujimoto, M. Kitajima, M. Natori, "Identification of three human type-II classic cadherins and frequent heterophilic interactions between subclasses of type-II classic cadherins", *Biochemical Journal*, 2000, vol. 349, p. 159-167.
12. N. Hertel, K. Krishna, M. Nuenberger, C. Redies, "A cadherin-based code for the divisions of the mouse basal ganglia", *Journal of Comparative Neurology*, 2008, vol. 508, p. 511-528. For a review of cadherins in morphogenesis and postulated cadherin adhesion mechanisms, see: J.M. Halbleib, W.J. Nelson, "Cadherins in development, cell adhesion, sorting, and tissue morphogenesis", *Genes and Development*, 2006, vol. 20, p. 3199-3214. For another example of morphogenesis involving a cadherin code comprised of type II classic cadherins, see: S.R. Price, N.V. De Marco Garcia, B. Rauscht, T.M. Jessell, "Regulation of motor neuron pool sorting by differential expression of type II cadherins", *Cell*, 2002, vol. 109, p. 205-216.
13. H. Hakonarson et al., "Common genetic variants on 5p14.1 associate with autism spectrum disorder", *Nature*, 2009, vol. 459, p. 528-533.
14. For a treatment of bilateral symmetry and cephalization, see: G.L. Grabowsky, "Symmetry, locomotion, and the evolution of an anterior end: a lesson from sea urchins", *Evolution*, 1994, vol. 48, p. 1130-1146.

University Requirements

Academic Honesty and Plagiarism

FIU Academic Misconduct Statement

Florida International University is a community dedicated to generating and imparting knowledge through excellence in teaching and research, the rigorous and respectful exchange of ideas, and community service. All students should respect the right of others to have an equitable opportunity to learn and honestly to demonstrate the quality of their learning. Therefore, all students are expected to adhere to a standard of academic conduct that demonstrates respect for themselves, their fellow students, and the educational mission of the University. All students are deemed by the University to understand that if they are found responsible for academic misconduct, they will be subject to the Academic Misconduct procedures and sanctions, as outlined in the Honors College Student Handbook.

Academic misconduct includes:

- *Cheating – The unauthorized use of books, notes, aids, electronic sources, or assistance from another person with respect to examinations, course assignments, field service reports, class recitations or other work; or the unauthorized possession of examination papers or course materials, whether originally authorized or not. Cheating violates both University and College codes.*
- *Plagiarism – The use and appropriation of another’s work without any indication of the source, and the representation of such work as the student’s own. Any student who fails to give credit for ideas, expressions or materials taken from another source, including Internet sources, commits plagiarism. Plagiarism violates both University and College codes.*
- *Unacceptable behavior – Students who show repeated or egregious disrespect for classmates or instructors, are disruptive, or consistently violate course rules are subject to the sanctions of the Honors College.*

Registration in this course implies an acceptance of and compliance with the Honors College policies for students and the FIU Code of Academic Integrity. Please refer to the following documents for additional information:

FIU Code of Academic Integrity –
<http://www.fiu.edu/~dwyere/academicintegrity.html>

FIU Honors College Student Handbook –
<http://honors.fiu.edu/handbook0910.html>

FIU Honors College Plagiarism Policy –
http://honors.fiu.edu/current_policy_plagiarism.html

Religious Observances

Every effort will be made, where feasible and practical, to accommodate students whose religious practices coincide with class requirements or scheduling. Please make sure to notify your instructor at the beginning of the semester of which dates you will be absent or any anticipated problems with completing course work.

Physical, Mental and Sensory Challenges

Every effort will be made, where feasible and practical, to accommodate students who are so challenged. Should you require accommodations, contact the Disability Resource Center, if you have not done so already.

Honors College Requirements

Registration in this course implies an acceptance of and compliance with the Honors College policies for students and the FIU Code of Academic Integrity.

Honors Citizenship Requirements

Beginning in Fall 2014, Honors College students are required to accumulate at least **20 citizenship points** each academic year (Fall and Spring) by attending Honors College activities. Students attending only one semester (Fall or Spring) are required to accumulate **10 citizenship points**. See <http://honors.fiu.edu/academics/policies/citizenship/>.

Student Portfolios

The Honors College will be using a portfolio method to assess students' learning outcomes. The portfolio allows for maximum flexibility in gauging student learning. Students decide (with instructor consultation) what "artifacts" or assignments to include for consideration in their portfolios to demonstrate successful achievement of each of five key student learning outcomes over the 4-year Honors experience. See www.honors.fiu.edu/portfolios.

Honors Education in the ARTS (HEARTS)

The HEARTS program is designed to give Honors College students opportunities to "explore and appreciate different artistic and cultural traditions and modes of artistic expression. HEARTS will also serve as a clearinghouse (and curatorial framework) for our students to experience the arts on campus and in the community by providing them with information about cultural activities and access to performances with free or discounted tickets. See <http://honors.fiu.edu/hearts/>.

Honors College Academic Misconduct Statement

In The Honors College, the term “honor” refers both to academic accomplishment and character. Students in Honors should therefore adhere to and be held to the highest standards of personal academic accountability. Academic dishonesty in any form, including plagiarism, is antithetical to the very definition of being an Honors student at FIU. Consequently, an Honors College student found responsible for academic misconduct will be dismissed from the College.

Procedures and Penalties

An Honors faculty member may bring charges of academic misconduct against an Honors student if the faculty member suspects plagiarism or other forms of academic misconduct. The faculty member will decide whether to pursue informal resolution, file formal resolution charges, or take no further action, and will follow the procedures outlined in the Honors College website (<http://honors.fiu.edu/academics/policies/>), and the Academic Misconduct Procedures, available at <http://www.fiu.edu/~oabp/misconductweb/1acmisconductproc.htm>.

Please refer to the following documents for additional information:

FIU Code of Academic Integrity – <http://www.fiu.edu/~dwyere/academicintegrity.html>.

FIU Honors College Student Handbook – <http://honors.fiu.edu/handbook0910.html>

FIU Honors College Plagiarism Policy – http://honors.fiu.edu/current_policy_plagiarism.html Courses designated as Global Learning courses (IDH 3034-3035) must list specific Global Learning outcomes. Assignments must be able to assess the students’ ability to demonstrate these outcomes. Questions on Global Learning should be addressed to Jose Rodriguez, rodrije@fiu.edu.

Global Learning Outcomes

Upper Division classes have been designated as Global Learning courses. For questions regarding GL requirements, please contact Allen Varela at the Honors College.

GL Learning Outcomes for IDH 3034-5

- **Global Awareness:** Students will be able to demonstrate knowledge of the interrelatedness of local, global, international, and intercultural issues, trends, and systems.
- **Course Learning Outcome:** Students will demonstrate knowledge of the interrelated global dynamics (social-cultural, political, economic, etc.) that shape aesthetics, values, and authority in diverse cultural contexts.
- **Global Perspectives:** Students will be able to develop a multi-perspective analysis of local, global, international, and intercultural problems.
- **Course Learning Outcome:** Students will be able to analyze the multiple global forces that shape their understanding of aesthetics, values, and authority — economic, political, sociological, technological, cultural, etc.
- **Global Engagement:** Students will be able to demonstrate a willingness to engage in local, global, international, and intercultural problem solving.
- **Course Learning Outcome:** Students will be able to develop solutions to local, global, international, and/or intercultural problems related to aesthetics, values, and authority.