Dr. Eric Charles Dykeman

Curriculum Vitae

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RESEARCH INTERESTS

My main research interests are focused on the mathematical modelling of RNA and its roles in assembly and replication control in the class of ssRNA viruses. I have expertise in the development of scientific software and have extensive knowledge of molecular dynamics, normal mode analysis, stochastic modelling, RNA kinetic folding prediction, and mathematical modelling of chemical kinetics. Additionally, I have interests in several pure mathematics fields such as group and graph theory and how they can be used to simplify computational problems in biology.

EDUCATION

09/2001 – 05/2008 *Arizona State University, Tempe AZ, USA*
Ph.D. Physics
Thesis: Atomistic Normal Mode Analysis of Large Biological Systems: Theory and Applications

09/1998 – 08/2001 *South Dakota School of Mines, Rapid City SD, USA*
B.Sc. Physics, Minor Mathematics
Honors: summa cum laude

PROFESSIONAL APPOINTMENTS

01/2017 – Present Lecturer Mathematics
University of York, UK, Department of Mathematics

01/2014 – 12/2016 Leverhulme Trust Early Career Research Fellow
University of York, UK, Department of Mathematics
During my research fellowship I developed a Log(n) method for stochastic modelling of RNA folding kinetics using the Gillespie method along with an assembly model for RNA viruses which explicitly accounts for the RNA sequence. Additionally, I developed novel bio-informatics tools for the analysis of Nex-Gen sequencing data of RNA-protein contacts.

07/2008 – 12/2013 Post-Doctoral Research Associate
University of York, UK, Department of Mathematics
My research project developed stochastic models of viral capsid assembly, in which group and graph theory played a central role. My post-doctoral research contributed to a paradigm shift in our understanding of the roles that RNA plays during assembly of ssRNA virions.

RESEARCH EXPERIENCE

09/2003 – 05/2008 Graduate Research Associate
Arizona State University
During my research, I developed a suite of scientific software packages in FORTRAN for molecular dynamics and normal mode analysis. I specifically considered applications to

viruses, for which applications of group theory played a crucial role. My application of these models to study how lasers could be used to destroy viral capsids was featured on the website of MSNBC, an American news program. In addition, I also had several projects on electronic structure calculations of peptide nano-tubes and modelling the DNA sequencing via AFM techniques.

GRANT FUNDING

05/2022 – 10/2022 EPSRC Impact Acceleration Account
Recoding mRNAs for Bespoke Protein Expression
Value: £3k

01/2014 – 12/2016 Leverhulme Trust Early Career Research Fellowship
Physical Virology: A Novel Approach to Virus Assembly and Evolution
Estimated Value: £180k

PATENTS AND IMPACT

A novel anti-viral strategy against RNA viruses; filed by the University of York on 5th September 2013 (GB1315785.4)

Virus Like Particle; filed by the University of York on 1st June 2017 (GB1708709.9)

TEACHING EXPERIENCE

01/2017 - Present University of York
Department of Mathematics
Modules
- Numerical Analysis – (Y3/H Level)
- Computational Finance – (Y4/M Level)
- C++ with Applications in Finance – (Y4/M Level)
- Mathematics for the Sciences III – (Y2/I Level)
- Mathematical Virology – (Y4/M Level)

Seminars/Tutorials
- Calculus – (Y1/C Level)
- Algebra – (Y1/C Level)
- Mathematical Skills – (Y1/C Level)

Module Development
- Numerical Techniques for Modelling Biological Systems – (Y4/M Level)
- Mathematical Virology – (Y4/M Level) I developed the representation theory portion of this module.
- Natural Sciences Summer Coding Camp – (A special 2-week lecture series on computational coding for the Natural Sciences)

09/2001 – 05/2008 Arizona State University
Department of Physics
Seminars/Tutorials/Laboratories (Taught as Teaching Assistant)
- General Physics 101 – (Y1 Algebra based general physics course)
- Physics I and II – (Y1 Trigonometry based course in Newtonian mechanics and E&M)

- University Physics I and II – (Y1 Calculus based course in Newtonian mechanics and E&M)
- Mathematical Methods in Physics I and II – (Y3 Course in advanced maths for physics majors)
- Physics I and II Laboratories – (Y1 Laboratories)
- University Physics I and II Laboratories – (Y1 Laboratories)

PH.D. SUPERVISION

05/2023	Sam Hill – Current
12/2019	Eva Weiss – (Joint with R. Twarock)
12/2019	Connor Hayden – (Joint with R. Twarock)

ACADEMIC CITIZENSHIP

01/2017 – Present
University of York Natural Sciences Programme
Pathway Leader for Chemistry/Maths/Physics Programme
I oversee the running of the Chemistry/Maths/Physics degree programme within the Natural Sciences at the University of York. I make regular reports to both the Mathematics BoS and Natural Science BoS on module issues and programme development.

07/2020 – Present
University of York Faculty Peer Review College
Mathematics, and Mathematical Biology Reviewer
Peer review of internal funding proposals for the University.

01/2017 – Present
University of York Natural Sciences Programme
Teaching Committee
Member of the teaching committee, where I oversee the teaching standards for the Natural Science degree programmes.

09/2019 – Present
Academic Editor
PLOS
Editor for PLOS journals where I handle manuscripts on virus biology, virus assembly, bioinformatics and other computational techniques.

PUBLICATIONS - In Preparation

Dykeman, E.C. Simulating Translational Control of Protein Synthesis by mRNA Secondary Structure. *Proc. Nat. Acad. Sci.* **In Preparation.**

Dykeman, E.C. Dissecting the Kinetics of tRNA Recharging by Amino-Acyl Synthases in Exponentially Growing E. Coli. *PLOS: Comp. Biol.* **In Preparation.**

Dykeman, E.C. An Algorithm for the Computational Prediction of the Co-Transriptional Fold of RNAs, *Nucleic Acids Res.* **In Preparation.**

Weis, E., Twarock R., & Dykeman E.C. Efficient RNA assembly and packaging in RNA bacteriophage MS2 is directed by a set of highly conserved packaging signals. *J. Mol. Biol.* **In Preparation.**

Chandler-Bostock, R., Clark, S., Bingham, R.J., Dykeman E.C., et al. Genome-regulated Assembly of a ssRNA virus Prepares It for Infection. *J. Mol. Biol.* **Submitted**.

PUBLICATIONS

[1] Hill, S.R., Twarock, R., & Dykeman, E.C. (2021) RNA The Impact of Local Assembly Rules on RNA Packaging in a T=1 Satellite Plant Virus. *PLOS: Comp. Biol*. **17**, e1009306.

[2] Fatehi, F., Bingham, R.J., Dykeman, E.C., et al. (2021) An Intracellular Model of Hepatitis B Viral Infection: An In Silico Platform for Comparing Therapeutic Strategies. *Viruses.* **13**, 11.

[3] Fatehi, F., Bingham, R.J., Dykeman, E.C., Stockley, P.G., & Twarock R. (2021) Comparing antiviral strategies against COVID-19 via multi-scale within host modelling. *Royal Soc. Open Sci.* **8**, e210082.

[4] Chandler-Bostock, R., Mata, C.P., Bingham, R.J., Dykeman, E.C., et al. (2020) Assembly of infectious enteroviruses depends on multiple, conserved genomic RNA-coat protein contacts. *PLOS: Pathogens.* **16**, e1009146

[5] Dykeman, E.C. (2020) A Stochastic Model for Simulating Ribosome Kinetics in vivo. *PLOS: Comp. Biol.* **16**, e1007618

[6] Bayfield, O.W., Kilmuk, E., Winkler, D.C., et al. (2019) Cryo-EM structure and in vitro DNA packaging of a thermophilic virus with supersized T=7 capsids. *Proc. Nat. Acad. Sci.* **116**, 3556-3561.

[7] Twarock, R., Bingham, R.J., Dykeman, E.C., & Stockley, P.G (2018) A Modelling Paradigm for RNA virus Assembly. *Curr. Opin. Virology* **31**, 74-81.

[8] Bingham, R.J., Dykeman, E.C., & Twarock, R. (2017) RNA Virus Evolution via a Quasispecies-Based Model Reveals a Drug Target with a High Barrier to Resistance. *Viruses*. **9**, 347.

[9] Borodavka, A., Dykeman, E.C., Schrimpf, W., & Lamb, D.C. (2017) Protein-mediated RNA folding governs sequence-specific interactions between rotavirus genome segments. *Elife* **6**, e27543.

[10] Dykeman, E.C. (2017) A model for viral assembly around an explicit RNA sequence generates an Implicit fitness landscape. *Biophys. J.* **113**, 506-513.

[11] Patel, N., White, S., Thompson, R.F., et al. (2017) HBV RNA pre-genome encodes specific motifs that mediate interactions with the viral core protein that promote nucleocapsid assembly. *Nature Microbiology* **2**, 17098.

[12] Shakeel, S., Dykeman, E.C., White, S.J., Ora, A., Cockburn, J.J.B., Butcher, S.J., Stockley, P.G. & Twarock, R. (2017) Genomic RNA folding mediates assembly of human parechovirus. *Nature Communications* **8**, 2041-1723.

[13] Zappa, E., Dykeman, E.C, Geraets, J.A & Twarock, R. (2016) A group theoretical approach to structural transitions of icosahedral quasicrystals and point arrays. *J. Phys. A: Mathemaical and Th.* **49**, 175203.

[14] Rolfsson, O., Middleton, S., Manfield, I.W., et al. (2016) Direct Evidence for Packaging Signal-Mediated Assembly of Bacteriophage MS2. *J. Mol. Biol.* **428**, 431-448.

[15] Stockley, P.G, White, S.J., Dykeman, E.C., et al. (2016) Bacteriophage MS2 genomic RNA encodes an assembly instruction manual for its capsid. *Bacteriophage* **6**, e1157666.

[16] Stewart, H., Bingham, R.J., White, S.J., Dykeman, E.C., Zothner, C., Tuplin, A.K., Stockley, P.G., Twarock, R. & Harris, M. (2016) Identification of novel RNA secondary structures within the hepatitis C virus genome reveals a cooperative involvement in genome packaging. Scientific Reports **6**, 22952.

[17] Dykeman, E.C. (2015) An implementation of the Gillespie algorithm for RNA kinetics with logarithmic time update. *Nuc. Acids. Res.***43**, 5708-5715.

[18] Geraets, J.A., Dykeman, E.C, Stockley, P.G., Ranson, N.A. & Twarock, R. (2015) Asymmetric Genome Organization in an RNA Virus Revealed via Graph-Theoretical Analysis of Tomographic Data. *PLOS: Comp. Biol.* **11**, e1004146.

[19] Patel, N., Dykeman, E.C et al. (2015) Revealing the density of encoded functions in a viral RNA. *Proc. Nat. Acad. Sciences.* **112**, 2227-2232.

[20] Zappa, E., Dykeman, E.C., & Twarock, R. (2014) On the subgroup structure of the hyperoctahedral group in six dimensions. *Acta. Cryst. A,* **70**, 5032-5044.

[21] Dykeman, E.C., Stockley, P.G. & Twarock, R. (2014) Solving a Levinthal's paradox for virus assembly identifies a unique antiviral strategy. *Proc. Nat. Acad. Sciences*. **111**, 5361-5366.

[22] Dykeman, E.C., Stockley, P.G. & Twarock, R. (2013) Packaging signals in two-single stranded RNA viruses imply a conserved assembly mechanism and geometry of the packaged genome. *J. Mol. Biol.* **425**, 3235-3249.

[23] Stockley, P.G., Twarock, R., Bakker, S.E., Barker, A.M., Borodavka, A., Dykeman, E.C., Ford, R.J., Pearson, A.R., Phillips, S.E.V., Ranson, N.A., Tuma, R. (2013) Packaging signals in single-stranded RNA viruses: nature's alternative to a purely electrostatic assembly mechanism. *J. Biol. Phys.* **39**, 277-287.

[24] Dykeman, E.C., Stockley, P.G. & Twarock, R. (2013) Building a viral capsid in the presence of genomic RNA. *Phys. Rev. E* **87**, 022717.

[25] Buttner, C.R., Chechik, M., Ortiz-Lombardia, M., Smits, C., Chechik, V., Jeschke, G., Dykeman, E.C., Benini, S., Alonso, J.C. & Antson, A.A. (2012). Structural basis for the dual role of a small terminase in a virus assembly. *Proc. Nat. Acad. Sciences*. **109**, 811-816.

[26] Bunka, D.H., Lane, S.W., Lane, C.L., Dykeman, E.C., Ford, R.J., Barker, A.M., Twarock, R., Phillips, S.E. & Stockley, P.G. (2011). Degenerate RNA Packaging Signals in the Genome of Satellite Tobacco Necrosis Virus: Implication for the assembly of a T=1 Capsid. *J. Mol. Biol.* **413**, 51-65.

[27] Dykeman, E.C., Grayson, N.E., Torapova, K., Ranson, N., Stockley, P.G. & Twarock, R. (2011). Simple rules for efficient assembly predict the layout of a packaged viral RNA. *J. Mol. Biol.* **408**, 399-407.

[28] Dykeman, E.C. & Sankey, O.F. (2010). Normal Mode Analysis and Applications in Biological physics. *J. Phys.: Condens. Matter* **22**, 423202.

[29] Morton, V.L., Dykeman, E.C., Stonehouse, N.J., Ashcroft, A.E., Twarock, R. & Stockley, P.G. (2010). The Impact of Viral RNA on Assembly Pathway Selection. *J. Mol. Biol.* **401**, 298-308.

[30] Dykeman, E.C. & Twarock, R. (2010). All-atom normal mode analysis reveals an RNA induced allostery in a bacteriophage coat protein. *Phys. Rev. E* **81**, 031908.

[31] Dykeman, E.C. & Sankey, O.F. (2010). Atomistic modeling of the low-frequency mechanical modes and Raman spectra of icosahedral viral capsids. *Phys. Rev. E* **81**, 021918.

[32] Dykeman, E.C., Stockley, P.G. & Twarock, R. (2010). Dynamic Allostery Controls Coat Protein Conformer Switching during MS2 Phage Assembly. *J. Mol. Biol.* **395**, 916-923.

[33] Dykeman, E.C. & Sankey, O.F. (2009). Vibrational energy funneling in viruses – simulations of impulsive stimulated Raman scattering in M13 bacteriophage. *J. Phys.: Condens. Matter* **21**, 505102.

[34] Dykeman, E.C. & Sankey, O.F. (2009). Theory of the low frequency mechanical modes and Raman spectra of the M13 bacteriophage capsid with atomic detail. *J. Phys.: Condens. Matter* **21**, 035116.

[35] Dykeman, E.C., Benson, D., Tsen, K.T. & Sankey, O.F. (2009). Simulations of impulsive laser scattering of biological protein assemblies: Application to M13 bacteriophage. *Phys. Rev. E* **80**, 041909.

[36] Dykeman, E.C. & Sankey, O.F. (2008). Low Frequency Mechanical Modes of Viral Capsids: An Atomisitc Approach. *Phys. Rev. Lett.* **100**, 028101.

[37] Dykeman, E.C., Tsen, K.T. & Sankey, O.F. (2007). Raman spectra and intensity predictions for cylindrical viruses. *Phys. Rev. E* **76**, 011906.

[38] Tsen, K.T., Dykeman, E.C., Sankey, O.F., Tsen, S.-W. D., Lin, N.-T. & Kiang, J.G. (2007). Probing the low-frequency vibrational modes of viruses with Raman scattering – bacteriophage M13 in water. *J. BioMedical Optics* **12**, 024009.

[39] Tsen, K.T., Dykeman, E.C., Sankey, O.F., Tsen, S.-W. D., Lin, N.-T. & Kiang, J.G. (2006). Raman scattering studies of the low-frequency vibrational modes of bacteriophage M13 in water – observation of an axial torsional mode. *Nanotechnology* **17**, 5474-5479.

[40] Tsen, K.T., Dykeman, E.C., Sankey, O.F., Tsen, S.-W. D., Lin, N.-T. & Kiang, J.G. (2006). Observation of the low frequency vibrational modes of bacteriophage M13 in water by Raman spectroscopy. *Virology Journal* **3**, 79.

INVITED TALKS

06/2021	Stochastic Modelling of the Ribosome/Transcriptome of a Cell, *Stochastic Models in Biology*, Venice Italy
10/2017	Packaging Signal Mediated Assembly: A Novel Target for Anti-viral Therapy, *3rd Workshop on Viral Dynamics,* Heidelberg, Germany
06/2017	An Implicit Fitness Landscape for Viral Evolution Based on RNA Virus Assembly, *ASV Satellite Meeting*, Madison, Wisconsin USA
10/2016	RNA Folding, Viral Assembly and Implicit Fitness Landscapes for Viral Evolution, *Workshop on self-assembly from atoms to life*, Tuxtla-Guiteriez, Mexico

07/2016 Evidence for a packaging signal mediated nucleation complex in bacteriophage MS2, *FASEB Virus Structure and Assembly*, Steamboat Springs, Colorado USA

01/2016 The Multiple roles for viral RNA packaging signals and their consequences for capsid assembly and evolution, *Mini-Symposium on protein nanocages*, Okinawa, Japan

10/2015 Assembly of ssRNA Viruses I: Identification of packaging signals and their role in assembly, *Mathematical Biosciences Institute*, OSU, Columbus Ohio USA

07/2015 Identification of packaging signals from Next-Gen data and their role in assembly, *Workshop on RNA structure function, and evolution*, Trieste, Italy

10/2014 The RNA folding problem in context of virus assembly, *Computational RNA Biology Workshop*, Cambridge, United Kingdom

05/2014 Virus Assembly Nature's way: A systems Approach, *4th Mathematical Virology Workshop*, York, United Kingdom

02/2014 Self-assembly of nanoshells around polymers: using insights from nature to engineer self-assembling systems, *Form and Function of Protein Nanoshells*, Leiden, Netherlands

12/2013 The multiple roles of viral RNA genomes in capsid assembly and viral replication, *CIDCATS Combating Infectious Diseases Seminar*, York, United Kingdom

03/2012 Using graph theory to identify genome organization and packaging mechanisms in ssRNA viruses, *Discrete and Topological Models in Molecular Biology*, Tampa FL, USA

08/2010 Modeling the cooperative roles of the genomic RNA in virus assembly, *3rd Mathematical Virology Workshop*, Ambleside, United Kingdom

07/2010 Cooperative effects of genome packaging and virus assembly in ssRNA viruses, *Society of Mathematical Biology, BIOMAT Conference*, Rio de Janeiro, Brazil

12/2008 Atomistic calculations of the low frequency vibrational modes of tubular and icosahedral viral capsids, *Institute of Physics Workshop on Viruses*, Durham, United Kingdom

04/2008 Calculation of low frequency mechanical modes of viral capsids with atomic detail, *ASU Department of Physics Nanoscale Science Series 2007-2008*, Tempe Arizona, USA

CONTRIBUTED TALKS

07/2015 Identification of packaging signals in a Human Picornavirus", *Phage and Virus Assembly Meeting,* Les Diablerets, Switzerland

09/2013 More than passive passengers: the roles of RNA packaging signals in virus assembly and evolution, *XXIII Conference on Phage Assembly*, Lake Arrowhead California, USA

10/2011 Multiple degenerate packaging signals in ssRNA viruses and their implications for assembly, *XXII Conference on Phage Assembly*, Port Aransas Texas, USA

09/2009 Characterization of viral assembly pathways from experiment and theory, *XXI Conference on Phage Assembly*, Veyrier-du-Lac, Annecy, France

04/2009 Vibrational flexibility of bacteriophage MS2 coat protein dimer, *Society for General Microbiology*, Harrogate, United Kingdom

03/2008 Low frequency mechanical modes of viral capsids with atomic detail, *American Physical Society March Meeting*, New Orleans Louisiana, USA

10/2007 Calculation of the low frequency mechanical modes of viral capsids with atomic detail, *American Physical Society Four Corners Meeting*, Flagstaff Arizona, USA

03/2007 Theoretical Raman spectra for viral particles in solution, Arizona Biophest, Tempe Arizona, USA

03/2006 Locating structural energy minimum of biological molecules in explicit solvent, *American Physical Society March Meeting*, Baltimore Maryland, USA

10/2003 Theoretical study of complex band structure of peptide nanotubes, *American Physical Society Four Corners Meeting*, Tempe Arizona, USA

CONTRIBUTED POSTERS

10/2016 A new method for constructing the partition function of an RNA sequence with application to viral genomes, *Computational RNA Biology*, Cambridge, United Kingdom

06/2014 Modeling Assembly in vivo: A solution to a Levinthal's paradox, *FASEB Virus Structure and Assembly*, Saxtons River, Vermont USA

06/2012 A Paradigm Shift in Virus Assembly: The Multiple Cooperative Roles of ssRNA genomes, *FASEB: Virus Structure and Assembly*, Saxtons River Vermont, USA

AWARDS & HONORS

05/2008 Marc Anderson Outstanding Doctoral Thesis Award, Department of Physics, ASU