Payal Ray, Ph.D.
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Summary: Widely engaged research scientist with experience in genetics, molecular biology and undergraduate science education.

EDUCATION

Ph.D., Department of Neuroscience **2009**
Northwestern University *Chicago, IL*
Dissertation: Role of pre-mRNA splicing in neurodegeneration

M.S. Biomedical Sciences **2002**
University of Delhi *Delhi, India*
Dissertation: Identification of novel heat shock proteins in *B. subtilis*

B.S. Biochemistry **2000**
University of Delhi *Delhi, India*

PROFESSIONAL EXPERIENCE

Visiting Assistant Professor **Aug 2015 - present**
Bowdoin College *Brunswick, ME*

- Developed two new courses, an upper level Genetics course and an introductory Biochemistry course, in keeping with the liberal arts style of education, namely promoting critical thinking and transferrable problem solving skills
  - Molecular Genetics course focused on the genetics of monogenic inherited diseases such as thalassemia, as well as complex disorders like diabetes. The course also highlights the social relevance and real-world applications to equip students with the insight to make informed decisions about personal health and public policy
  - Biochemistry of Health and Disease introduced non-science majors to the process of scientific analysis and deduction, using actual human health/disease issues, such as, lactose intolerance and effects of artificial sweeteners on metabolism
- Designed projects in genetics and molecular biology for student researchers to develop their research skills

TEACHING AND MENTORING ACTIVITIES

Course Coordinator, Genomics **Aug - Dec 2013**
University of the District of Columbia *Washington, D.C.*

- Developed course content, identified speakers, organized lectures and lab, led discussion and exam review sessions, designed and graded exams and evaluated term papers.
- Conducted workshop on effective teaching strategies for the instructors

Journal Club Leader **Jul 2013**
National Institutes of Health *Bethesda, MD*

- Organized and conducted a journal club for summer students at the NIH

Mentor, Community College Summer Enrichment Program (CCSEP) **Jun - Aug 2013**
National Institutes of Health *Bethesda, MD*

- Developed independent research project for intern
- Mentored and supervised CCSEP intern in the laboratory

Instructor, FAES Graduate School at NIH **Jan 2012 - Dec 2014**
National Institutes of Health *Bethesda, MD*

- Developed course material and co-taught "Bootcamp for University Teaching" course – a practical approach to introduce students to principles of effective teaching and learning strategies
- Lectured students in "Biochemistry for Layman" course using a case studies approach
- Served as guest lecturer for Genetic Engineering course

Teaching Fellow, Integrated Life Sciences **Apr 2013**
University of Maryland *College Park, MD*

- Led a discussion section for undergraduate students in the "Genes and Genomes" course using the C.R.E.A.T.E approach, which teaches students to analyze primary literature in an effort to develop critical thinking skills and content integration abilities

Volunteer Mentor, National Youth Leadership Forum **Aug 2011**
Office of Intramural Education and Training, National Institutes of Health *Bethesda, MD*

- Led high school students on lab tour and shared scientific experience to generate student interest in STEM subjects and encourage leadership skills

Adjunct Instructor **Jan - Sep 2010**
Biotechnology Department, Fortis College *Landover, MD*

- Courses taught include Introductory Biotechnology, Ethics in Bioscience, Microbiology and Physiology, Biochemistry and Cell Biology, Professional Development Course

Preparing Future Faculty (PFF) Participant **Sep 2008 - 2009**
Northwestern University *Chicago, IL*

- Co-taught General Genetics course at Northeastern Illinois University, Chicago, IL
- Lectured students in General Genetics class and laboratory using active learning strategies (e.g. small group discussion and one minute papers) and conducted exam review sessions
- Participant in Graduate Teaching Certificate Program – a year long program that allows participants to develop, practice and reflect on teaching methods

Teaching Assistant, Neuropharmacology of Brain Disorders **May - Aug 2008**
Northwestern University *Chicago, IL*

- Maintained course website using the online course management system, Blackboard

Teaching Assistant, Cell Biology and Introductory Biology **Jan 2003 - May 2005**
Vanderbilt University *Nashville, TN*

- Planned and organized experiments for the laboratory, designed laboratory manual
- Assisted students in the laboratory
- Lectured students in the laboratory, designed and graded problem sets and final exam

HONORS AND AWARDS

Fellows Award for Research Excellence **June 2013**
Office of Intramural Training and Education, National Institutes of Health *Bethesda, MD*

NIH Postdoctoral Mentor Award **Feb 2013**
National Institutes of Health *Bethesda, MD*
Junior Research Fellowship **Jun 2002**
Delhi University *Delhi, India*

- Awarded by Council for Scientific and Industrial Research, India.
  Rank: Top 5 percentile (in total of 20,000 applicants)

RESEARCH EXPERIENCE

Postdoctoral Fellow **Jan 2011 - Jul 2015**
Eunice Kennedy Shriver National Institute of Child Health and Human Development *Bethesda, MD*

- Designed and executed a project to identify and characterize novel DNA-binding proteins necessary for epigenetic regulation of gene expression in *Drosophila melanogaster*
- Established and standardized a method for identification of DNA binding proteins using an approach that combined affinity purification and mass spectrometric analysis

Graduate Research Assistant **Aug 2002 - Dec 2009**
Northwestern University *Chicago, IL*

- Developed *Drosophila* model of neurodegenerative diseases including *Amyotrophic Lateral Sclerosis (ALS)* and *Retinitis Pigmentosa (RP)*
- Identified and characterized trans-acting factors regulating Tau Exon10 splicing in Frontotemporal Dementia
- Executed a project to characterize the molecular basis of aggression using *Drosophila melanogaster* as a model system
- Supervised undergraduate and high school researchers in sub-projects

LEADERSHIP AND EXTRACURRICULAR ACTIVITIES

- **Service at National Institutes of Health** *Bethesda,MD*
  Editor, NIH Fellows Editorial Board **Nov 2011 - 2014**
  Edited and reviewed several scientific and non-scientific manuscripts for grammar and readability
  Contributing Writer, NIH Postdoc Newsletter **Jul 2011 - 2015**
  Contributing Writer, NICHD Connection Newsletter **May 2011 - 2015**
  Judge, NIH Postbac Poster Competition **May 2011**
  Committee member, NICHD Fellows Retreat Committee **May 2011-2013**
  Selected speakers, established contact with speakers, organized career discussion panels, and collaborated with team members for putting together a 75-attendee retreat

Participant in workshops organized by Office of Education, NICHD
National Institutes of Health *Bethesda, MD*

- College Teaching for the 21st Century **Aug 2012**
  Led by Dr. Boots Quimby
  Integrated Life Sciences Program
  University of Maryland
- Doing Real Work, not Homework **Mar 2012**
  Led by Dr. Brain Coppola
  Arthur F. Thurnau Professor
  Department of Chemistry
  The University of Michigan

- Overcoming apathy and creating excitement in the classroom **Sep 2011**
  Led by Todd Zakrajsek, Ph.D.,
  Executive Director, Center for Faculty Excellence
  University of North Carolina at Chapel Hill

- **Science Fair Judge** **Dec 2008**
  North-Grand High School *Chicago, IL*

TECHNICAL SKILLS

- *Molecular Biology and Biochemistry* - PCR, western blot, cloning, Chromatin immunoprecipitation (ChIP and ChIP-Seq), gel shift assay
- *Genetics* - yeast two-hybrid, yeast one-hybrid, Drosophila genetics
- *Cell biology* - Mammalian cell culture, primary cortical neuron culture, S2 cell culture, immunohistochemistry, in-situ hybridization, paraffin sectioning
- *Imaging and microscopy* - Confocal microscopy, epifluorescence
- *Software* - Image J, Adobe Illustrator, Metamorph, Autoquant, Partek

PUBLICATIONS

P. Ray, S. De, A. Mitra, K. Bezstarosti, J. A. A. Demmers, K. Pfeifer, J. Kassis, Combgap contributes to recruitment of Polycomb group proteins in *Drosophila*. (Under revision from PNAS)

R. Benabentos, **P. Ray**, D. Kumar, CBE-Life Sciences Educ Addressing Health Disparities in the Undergraduate Curriculum: An Approach to Develop a Knowledgeable Biomedical Workforce. CBE-Life Sci. Ed., Vol. 13, 1–5, Winter 2014

K. Ruirui, **P. Ray**, M. Yang, P. Wen, L. Zhu, J. Liu, K. Fushimi, A. Kar, Y. Liu, R. He, D. Kuo, J. Y. Wu. Alternative Pre-mRNA splicing. 2013. Cell Death, and Cancer, RNA and Cancer, 181-212; Editor Jane Y. Wu), Springer Link

P. Ray, A. Kar, K. Fushimi, N. Havlioglu, J.Y. Wu. PSF suppresses tau exon 10 inclusion by interacting with a stem-loop structure downstream of exon 10. 2011. J Mol Neurosci., 45(3):453-66

W. Guo, Y. Chen, X. Zhou, A. Kar, **P. Ray**, X. Chen, E.J. Rao, M. Yang, H. Ye, L. Zhu, J. Liu, M. Xu, Y. Yang, C. Wang, D. Zhang, E.H. Bigio, M. Mesulam, Y. Shen, Q. Xu, K. Fushimi, J.Y. Wu. An ALS-associated mutation affecting TDP-43 enhances protein aggregation, fibril formation and neurotoxicity. 2011. Nat Struct Mol Biol., 18(7):822-30

A. Kar , K. Fushimi, X. Zhou, **P. Ray**, C. Shi, X. Chen, Z. Liu, S. Chen, J.Y. Wu. RNA helicase p68 (DDX5) regulates tau exon 10 splicing by modulating a stem-loop structure at the 5' splice site. 2011. Mol Cell Biol., 31(9):1812-21

A. Joselin, L. Wang, X. Gao, A. Kar, **P. Ray**, A. Bateman, A. M. Goate and J. Y. Wu. Progranulin promotes neurite outgrowth and neuronal differentiation by regulating GSK-3b. 2010. Protein Cell.1(6):552-62)

P. Ray, E. A. Woodruff III, A. Basha, J.Y. Wu. The *Drosophila* homolog of the splicing factor Prp31 is essential for retinal development. 2010. Protein Cell.1(3):267-74

Y. Li, **P.Ray**, E.J. Rao, C.Shi, J.Y. Wu. A *Drosophila* model for TDP-43 proteinopathy. 2010. PNAS, 107(7):3169-74

K. Fushimi, **P. Ray**, A. Kar, L.Wang, L. Sutherland, J. Y. Wu**.** Up-regulation of the proapoptotic caspase 2 splicing isoform by a candidate tumor suppressor, RBM5. 2008 PNAS, 105(41):15708-13

SELECTED CONFERENCE PRESENTATIONS

P.Ray and J.A. Kassis. Identification and characterization of Combgap as a novel DNA binding protein necessary for epigenetic silencing by Polycomb group proteins. Northeast Regional Chromosome Pairing Conference, Boston MA, 2015

P.Ray and J.A. Kassis. Identification and characterization of Combgap as a novel DNA binding protein necessary for epigenetic silencing by Polycomb group proteins, Gordon Research Conference, Chromatin Structure and Function, Boston MA, 2014

P.Ray and J.A. Kassis. Identification and characterization of DNA binding proteins necessary for epigenetic silencing by Polycomb group proteins, 54th Annual Drosophila Research Conference, Washington D.C., 2013

Teaching Philosophy **Payal Ray, Ph.D.**

"The whole purpose of education is to turn mirrors into windows" these words by the journalist, Sydney Harris resonate with me and I believe that teachers are responsible for opening that window. In all the classes that I teach, I strive to make students see the connection between the material that they are learning and how it is applied in everyday world by providing specific real life examples. I also aim to teach my students how to think critically about a given topic or problem because strong critical-thinking skills are essential in any profession.

The two most essential components of my teaching style are an active classroom and collaborative learning. These are imperative to my teaching philosophy of connecting the classroom to the outer world. I believe active hands-on teaching and student–led discussions are key elements to not only pique student interests in a subject matter but also encourage them to seek out knowledge on their own.
I believe that all classes should include thought-provoking issues taken from current events, news articles, research articles and personal experiences that relate the concepts taught in the class to everyday life events. For example, I often ask students to bring in 'science in the news' articles for classroom discussions. This strategy is effective in showing the students how abstract concepts learnt in the class are being applied to something real and tangible. For a non-science majors class, titled Biochemistry of Health and Disease, after the introductory lecture on the basics of glucose regulation, students participated in a group activity (adapted from the CDC website) to explain the effect of insulin and glucagon on glucose levels. Subsequently, students watched videos about Type1 and Type 2 diabetes from Mayo Clinic, and worked in pairs to complete a worksheet on glucose regulation. This hands-on activity helped them to understand the science behind glucose metabolism to achieve a deeper understanding of the reasons for increase in obesity and Type 2 diabetes in the world population.

In my classroom I rely heavily on strategies like group discussions, think-pair-share, one-minute papers to engage students. I believe students learn best when they are responsible for teaching the material to each other as that puts the responsibility of learning on them. Additionally, I often assign reading assignments to students and begin the class by discussing important points from the homework. This technique encourages even the most reluctant student to read up because they do not want to be lost in the classroom. I also use case studies to encourage discussions in the classroom, e.g. in an upper-level Genomics class a case study on the genetics of cystic fibrosis served as both a class discussion activity and an exam review session.

I implemented the C.R.E.A.T.E method of analyzing primary research literature in a Genetics course and found it to be very useful in motivating students to step out of their comfort zone and 'work' with the material at hand. Using this method, I assigned the introduction of a paper to be read as homework and in the class, I asked the students to define the gap in the knowledge and the hypothesis that the paper was testing. Thereafter, the students worked in groups to design an experiment that should be performed to test the hypothesis and eventually, compared their prediction with the experiments reported in

the paper. By letting the students analyze the data and propose further experiments, this method allows them to apply the concepts learned during the course towards cutting-edge research questions. Consequently, the students develop a deeper understanding of the material.

An important part of teaching is assessment and I align my tests with the learning outcomes for the course. Using the Bloom's taxonomy as a guide, I design my test questions to test the students at both lower and higher order cognitive skills, for example, in an assessment for a upper-level genetics course, I asked students to (1) explain Mendel's laws (knowledge); (2) map the distance between two loci given the recombination frequency (application); (3) predict the effect of mutation in methyltransferase on gene expression and design a drug to block that effect (synthesis). In addition, I also believe in formative assessment and use exit cards as an assessment tool in every class. Students are asked to write down the answers to a couple of key questions at the end of the lecture on an index card along with any questions or comments. They have the option of turning in anonymous cards. This technique helps me to monitor student learning on a regular basis and get instant evaluation instead of relying solely on mid-semester or final assessments.

In my opinion, the role of a teacher is to provide the best possible environment for a student to learn. A teacher should strive to cultivate curiosity, self-confidence and imagination of the students. Additionally, as higher educators with advanced scientific training, it is our responsibility to pass our knowledge, training and experience to the students. Therefore, as a teacher I aim to commit myself to ensuring that my students not only learn the concepts, but also learn how to apply those principles to scientific problems.

Payal Ray, Ph.D.

Research Interests: Molecular determinants of epigenetic regulation in *Drosophila melanogaster*

Polycomb group proteins (PcG) are a class of transcriptional regulators that mediate the heritable repression of gene expression by post-translational modification of histone proteins. PcG proteins are organized into two multi-protein complexes known as PcG Repressive Complex 1 and 2 (PRC1 and PRC2) that function to repress transcription of genes involved in development, cellular differentiation and cell proliferation. PRC2 is responsible for trimethylation of lysine27 of the histone H3 subunit (referred to as H3K27me3) while PRC1 deposits the ubiquitin mark on lysine119 of histone H2A (H2AK119Ub), both of which are marks of repressive chromatin[1-3]. Studies have reported that in Drosophila, PRC1 and 2 are recruited to specific DNA sequences known as PcG response element (PRE) by the cooperative action of Pho and several other DNA-binding proteins (Fig 1) [4-6]. However, we do not know the identities of all the cofactors involved in this process.

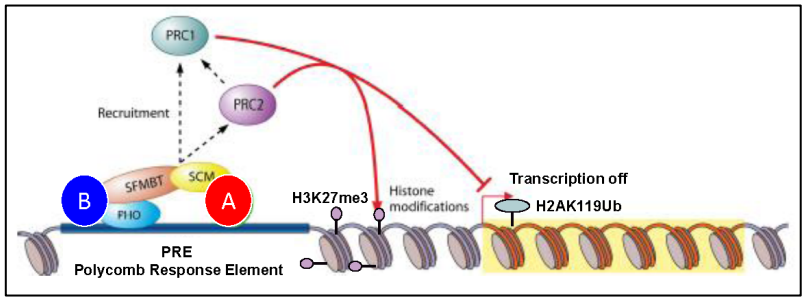

Fig1. Adapted from Kassis and Kennison, Mol Cell Biol 2010, Model for recruitment of PRC1 and 2 to PRE. Pho forms a complex with Sfmbt and binds to PRE. Other cofactors (Scm) and DNA binding proteins (indicated by A and B) interact with Pho to regulate recruitment of the complexes.

By identifying the DNA-binding proteins that are essential for PRC recruitment to PREs my research aims to advance our mechanistic understanding of how PcG proteins exert their function.

Preliminary data As a first step in understanding the recruitment of PRCs I aimed to identify the DNA-binding proteins that interact with the Drosophila *engrailed* PRE, a well-characterized PcG target [7]. I performed an oligomer-based affinity pull-down coupled with Mass Spectrometry (MS) using a fragment of the *engrailed* PRE. MS analysis identified 25 candidate proteins that specifically bound to the *engrailed* PRE. I characterized one of the candidate proteins, Combgap, which has been previously reported to repress the expression of a PcG target gene, *Cubitus interuptus* but the mechanism of this repression was unknown[8-9]. My studies showed that Combgap partially colocalized with the PRE-binding protein Spps on polytene chromosomes, which suggests an interaction of Combgap with the PcG machinery. ChIP-seq (Chromatin Immunoprecipitation- sequencing) analysis revealed that Combgap binds at a subset of PREs within the Drosophila genome. In biochemical experiments Combgap showed an interaction with the PRC1 component Ph (Polyhomeotic). A reduction in Combgap levels leads to decreased recruitment of Ph at certain PcG targets e.g. Abd-B, suggesting a role of Combgap in PRC1 recruitment[10].

I propose to investigate the role of the other putative target proteins in regulating PcG recruitment. I anticipate students will learn how to screen through these candidates and validate the binding to PRE by using a variety of genetic, immunohistochemical and biochemical analyses (some of the approaches are described below).

1.Define the role of Rrp1 in PcG repression My initial studies will focus on recombination repair protein 1 (Rrp1), the top hit in the MS analysis. Rrp1 is an endonuclease that functions in homologous recombination [10]. Studies have reported the involvement of PRC components in double-stranded break repair [11-12], however, this would be the first evidence of an endonuclease involved in recruitment of PRCs.

1a. Examine the presence of Rrp1 at PREs I have generated a Rrp1-specific antibody and students will perform co-staining of Rrp1 with known PRE binding proteins on polytene chromosomes to determine if Rrp1 co-localizes at PcG targets. Subsequently, Rrp1 localization at PREs of specific PcG targets can be examined by ChIP assay. Since the difficult and time-consuming step of generating an antibody has already

been done, I believe students will be able to complete these experiments in a relatively short time. Students will also learn fluorescence microscopy and chromatin immunoprecipitation techniques.

1b. Define the function of Rrp1 at PREs Defects in PRC recruitment can lead to de-repression of PcG target genes[13] therefore, I expect students to be able to observe misexpression of these target PcG genes in flies carrying Rrp1 mutations. In addition, students can test for Rrp1 function at PREs by examining the levels of various PRC components at the PREs by ChIP assay in Rrp1 mutants or after knockdown of Rrp1 transcript by treatment with RNAi.

1c. Examine Rrp1 interaction with PcG mutants. Studies have reported genetic interactions between PcG proteins[14], therefore students will cross Rrp1 mutants flies with PcG mutants (e.g. Ph or Pho mutants) and screen for exacerbation of Polycomb phenotypes. I have generated transgenic lines overexpressing tagged versions of Rrp1 and plan to utilize these lines to further investigate interactions of Rrp1 with other PRC components using biochemical methods.

2. Delineate the role of other putative DNA-binding proteins in PcG repression. I will examine the role of other candidate proteins in PRC recruitment and PcG-mediated silencing (using a similar strategy as outlined in Aim1). Generation of specific antibody will require time therefore students will screen the remaining candidates by crossing available mutants (from Bloomington Stock center) to flies carrying mutations in PcG members and screen for exacerbation of Polycomb phenotypes. Mutants in candidate genes will be examined for levels of PRC components present at the PREs, e.g. Polyhomeotic (a component of PRC1), H3K27me3 (a functional read-out of PRC2 recruitment) or Pho, by ChIP assay. Following this, potential candidate proteins will be followed up by generation of antibodies for experiments similar to those outlined in Aim 1a.

References

1. Ringrose L, Paro R (2004) Epigenetic regulation of cellular memory by the Polycomb and Trithorax group proteins. Annu Rev Genet 38: 413–443.

2. Schwartz YB, Pirrotta V (2007) Polycomb silencing mechanisms and the management of genomic programmes. Nat Rev Genet 8: 9–22.

3. Simon JA, Kingston RE (2009) Mechanisms of Polycomb gene silencing: knowns and unknowns. Nat Rev Mol Cell Biol 10: 697–708.

4. Kassis and Kennison (2010) Recruitment of Polycomb complexes - A role for Scm. Mol Cell Biol. Jun 2010; 30(11): 2581–2583.

5. Wang L, Jahren N, et al., (2010) Comparative analysis of chromatin binding by Sex Comb on Midleg (SCM) and other polycomb group repressors at a Drosophila Hox gene.. Mol Cell Biol. Jun; 30(11):2584-93.

6. Schuettengruber, B., Ganapathi, M., et al (2009). Functional Anatomy of Polycomb and Trithorax Chromatin Landscapes in *Drosophila* Embryos. *PLoS Biology*, *7*(1), e1000013.

7. Moazed D, O'Farrell PH. (1992) Maintenance of the engrailed expression pattern by Polycomb group genes in Drosophila. Development. 1992 Nov;116(3):805-10.

8. Campbell GL, Tomlinson A. (2000) Transcriptional regulation of the Hedgehog effector CI by the zinc-finger gene *combgap*. Development. Oct;127(19):4095-103.

9. Svendsen PC, Marshall SD, et al., (2000) The *combgap* locus encodes a zinc-finger protein that regulates *cubitus interruptus* during limb development in Drosophila melanogaster. Development. Oct;127(19):4083-93.

10. Ray P, De S, et al., Identification of Combgap as a DNA-binding protein required for PcG mediated gene silencing (manuscript in preparation).

11. Sander, M., Lowenhaupt, K., et al., (1991). Drosophila Rrp1 protein: an apurinic endonuclease with homologous recombination activities. Proc. Natl. Acad. Sci. U.S.A. 88(): 6780--6784.

12. Schuettengruber B, Martinez AM, et al., (2011) Trithorax group proteins: switching genes on and keeping them active.Nat Rev Mol Cell Biol. Nov 23;12(12):799-814.

13. Vissers JH, van Lohuizen M, et al., (2012) The emerging role of Polycomb repressors in the response to DNA damage. J Cell Sci. Sep 1;125 (Pt 17):3939-48.

14. Busturia A1, Lloyd A, Bejarano F, Zavortink M, Xin H, Sakonju S. (2001) The MCP silencer of the Drosophila Abd-B gene requires both Pleiohomeotic and GAGA factor for the maintenance of repression. Development. Jun;128(11):2163-73.

15. Brown JL1, Kassis JA (2010) Spps, a Drosophila Sp1/KLF family member, binds to PREs and is required for PRE activity late in development. Development. Aug 1;137(15):2597-602.

Contact Information for References

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