

Dr. Nandana Bhardwaj

Research Scientist (Associate)

Department of Biotechnology

National Institute of Pharmaceutical Education and Research (NIPER)-Guwahati

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Research Interests:

- Biomaterials (matrix design and processing)
- Tissue Engineering (human tissues/grafts implants and devices)
- 3-D bioprinting (for development of implantable tissues and organs)
- Polymer blends and composites (tissue engineering and biomedical applications)
- Human Stem Cells Based Repair (matrix and factor guided differentiation)
- Drug Delivery (scaffolds, hydrogels, nanoparticles, films, micro-beads)
- Advanced Bioinspired Materials (biosensors, chemiresistive sensors)
- Nanotechnology (Bio-nanocomposites, nanoparticles, nanofibers)
- *In vitro* tissue/organ/disease models

Academic Qualifications:

2012: Ph. D. in Biotechnology (Biomaterials and Tissue Engineering)

Institution: Department of Biotechnology, Indian Institute of Technology (IIT) Kharagpur

Specialization: Biomaterials, Stem cells, Bioengineering and Tissue Engineering

Supervisor: Professor Subhas C. Kundu

Thesis title: “Silk fibroin/chitosan polyelectrolyte complex porous scaffolds as biomaterial for tissue engineering applications”.

2006: M. Sc. in Biotechnology - (University 3rd Rank holder)

Institution: Department of Biotechnology, H. P. University, Shimla

Specialization: Animal Biotechnology

Supervisor: Professor Reena Gupta

Thesis title: “Optimization of production and reaction conditions of pectin lyase from *B. fulva* (MTCC-505)”.

2003: B. Sc. in Industrial Microbiology - (University 2nd Rank holder)

Institution: Avila Convent (Patna Womens College), Patna University, Patna.

Professional Experience:

- **2018-Till date:** Research Scientist (Associate), National Institute of Pharmaceutical Education and Research (NIPER)-Guwahati.

Project: “3D bioprinting and development of high throughput *in vitro* disease models for disease prognosis and drug screening”.

- **2013- 2017:** DBT-BioCARE Early Career Scientist (Principal Investigator), Institute of Advanced Study in Science and Technology (IASST), Guwahati.

Project: “North - East origin silk based 3-D co-culture model for cartilage tissue repair”.

- **2012-2013:** Post Doctoral Research Fellow, Nanyang Technological University, Singapore. **(Advisor: Professor Nam-Joon Cho)**

Project: “Development of silk fibroin/human hair keratin composite 3D matrices as dermal substitute for skin repair and regeneration”.

- **May, 2009- September, 2009:** Visiting research exchange Graduate student at University of California, San Diego, USA, and Tufts University, USA, Financially supported by Indo-US Science and Technology Forum (IUSSTF). **(Advisor: Professor Robert L. Sah)**

Project: “Development of silk fibroin/chitosan blended scaffolds for cartilage tissue repair”.

- **June, 2007- April, 2012:** Doctoral Student at Department of Biotechnology, Indian Institute of Technology Kharagpur (IIT Kharagpur), India. Supported by DBT (JRF and SRF) fellowship. Broad area of research: Tissue Engineering & Biomaterials. **(Advisor: Professor Subhas C. Kundu)**

Thesis title: “Silk fibroin/chitosan polyelectrolyte complex porous scaffolds as biomaterial for tissue engineering applications”.

Teaching Experience:

- **Lab teaching assistant**, IIT Kharagpur (2007-2011) for B. Tech and M. Tech classes (Genetics - BT31007; Cell and Molecular Biology-BT23002 and Bioinformatics–BT31006).
- **Instructor** (National Workshop on Bioinformatics 2007-2011), IIT Kharagpur.

Sponsored Projects:

- **“North - East origin silk based co-culture 3-D model for cartilage tissue repair”** project under DBT-BioCARE Women Scientists Scheme, Department of Biotechnology, Government of India **(Involved as Principal Investigator)**. (2013-2017).

Awards and Achievements:

- Received **DBT BioCARE Early Career Scientist Award** supported by a high value research grant (April, 2013).
- My research work “**Electrospinning: A fascinating fiber fabrication technique**” published in **Biotechnology Advances** Journal awarded “**Top Cited Article, 2009-2011**”. Total 2300+ citations.
- **Awarded** certificate for **outstanding contribution** in **reviewing** by **Elsevier** in corporation with **Society of Burns and Injuries** (March, 2017).
- My research work “**Silk fibroin-keratin based 3D scaffolds as a dermal substitute for skin tissue engineering**” published in Journal “**Integrative Biology**” was selected as “**FRONT COVER PAGE ARTICLE**”.
- My research work “**Silk fibroin-keratin based 3D scaffolds as a dermal substitute for skin tissue engineering**” received high rating in Peer-Review and highlighted as “**Integrative Biology (RSC) HOT Articles 2014**”.
- **Best poster award** for research work entitled “**Biomimetic mulberry and non-mulberry silk sheets for cardiac patch applications**” at International Conference of Young Researchers on Advanced Materials (**IUMRS-ICYRAM 2016**), **December 11-15, Indian Institute of Science, Bangalore, India.**
- **Nature India** special research highlight for my research work titled “**Silk protein hydrogels repair cartilage**” (doi:10.1038/nindia.2016.137).
- **Nature India** special research highlight for my research work titled “**Silk proteins help regenerate blood vessels**” (doi: 10.1038/nindia.2016.92).
- **Nature India** special research highlight for my research work titled “**Scaffolds for stem cells to grow cartilage**” (doi:10.1038/nindia.2012.43).
- **Nature India** special highlight for my research work titled “**Scaffolds to grow cartilage**” (doi:10.1038/nindia.2011.138).
- Awarded **ICMR, DBT and CSIR** travel grant for attending Tissue Engineering and Regenerative Medicine International Society Meeting (**TERMIS-AP**) Annual Conference from 23rd-26th October, 2013, China.
- **Nanyang Institute of Technology in Health and Medicine (NITHM) Post-doctoral fellowship** at Nanyang Technological University, Singapore (2012-2013).
- Awarded **DST travel grant** for attending International Conference of Tissue Engineering and Regenerative Medicine International Society meeting, Singapore (**TERMIS-AP**) (August, 3-5 August, 2011).
- Research Fellowship supported from **Indo-US Science and Technology Forum (IUSSTF)** for carrying out research in **University of California, San Diego (UCSD), USA** as research exchange graduate (May, 2009-September, 2009)

- Awarded **DBT-Junior Research Fellowship** (2007-2009) & **DBT-Senior Research Fellowship** (2009- 2011).
- Qualified DBT-Biotechnology Entrance Test (**DBT-BET, 2007**) for **DBT-Junior Research Fellowship & DBT-Senior Research Fellowship**.
- Qualified **GATE, 2007 (98.26 percentile score and AIR 195)**
- Qualified the Joint CSIR (Council of Scientific & Industrial Research)-UGC National Eligibility Test (NET) for the award of Lectureship in Life Sciences, India (**CSIR-UGC-NET, Dec, 2006**)
- Awarded **DBT fellowship** for Masters in Biotechnology (2004-2006)
- Qualified **All India Entrance for Masters in Biotechnology conducted by JNU, New Delhi, 2004.**

List of Publications (H-index-13, Citations-3199):

1. Chakravarty S, Gogoi B, Mandal BB, **Bhardwaj N***, Sarma NS. Silk fibroin as a platform for dual sensing of vitamin B₁₂ by optical and electrical impedimetric techniques. *Biosensors and Bioelectronics* (2018), 112: 18-22. (IF-8.173) (*Corresponding author).
2. Gilotra S, Chouhan D, **Bhardwaj N**, Nandi SK, Mandal BB. Potential of silk sericin - based nanofibrous mats for wound dressing applications. *Materials Science and Engineering C* (2018), 90: 420-432. (IF-5.080).
3. **Bhardwaj N***, Chouhan D, Mandal BB. Tissue engineered skin and wound healing: current strategies and future directions. *Current Pharmaceutical Design* (2017), 23: 3455-3482 (IF-2.757, 6 citations), (*Corresponding author).
4. Singh YP, Adhikary M, **Bhardwaj N**, Bhunia B, Mandal BB. Silk Fiber Reinforcement Modulates *in vitro* chondrogenesis in 3D composite scaffolds. *Biomedical Materials* (2017), 12: 045012 (IF-2.897, 3 citations).
5. **Bhardwaj N***, Singh YP, Devi D, Kandimalla R, Kotoky J, Mandal BB. Potential of silk fibroin/chondrocyte constructs of muga silkworm *Antheraea assamensis* for cartilage tissue engineering. *Journal of Material Chemistry Part B* (2016), 4:3670-3684. (IF-4.776, 24 citations), (JMC-B Top cited author 2016, Most downloaded articles). (*Corresponding author).

6. Chakravarty S[#], **Bhardwaj N[#]**, Mandal BB, Sarma NS. Silk Fibroin-carbon nanoparticle composite scaffolds: a cost Effective supramolecular ‘Turn Off’ chemiresistor for nitro aromatic explosive vapors. *Journal of Material Chemistry Part C* (2016), 4: 8920-8929. (IF-5.976, 7 citations) ([#]Equal contribution).
7. Jadi P, **Bhardwaj N**, Mandal BB. Cross-linked silk sericin-gelatin 2D and 3D matrices for prospective tissue engineering applications. *RSC advances* (2016) 6: 105125-105136. (IF-2.936, 2 citations)
8. Singh YP, **Bhardwaj N**, Mandal BB. Potential of agarose/silk fibroin blended hydrogel for *in vitro* cartilage tissue engineering. *ACS Applied Materials & Interfaces* (2016) 8: 21236–21249 (IF-8.090, 30 citations). (Research highlight featured in Nature India)
9. Singh SK, Bhunia BK, **Bhardwaj N**, Gilotra S, Mandal BB. Reloadable Silk-Hydrogel Hybrid Scaffolds for Sustained and Targeted Delivery of Molecules. *Molecular Pharmaceutics* (2016)13:4066-4081. (IF-4.556, 5 citations).
10. Gupta P, Adhikary M, Christakiran J, Kumar M, **Bhardwaj N**, Mandal BB. Biomimetic, osteoconductive non-mulberry silk fiber reinforced tricomposite scaffolds for bone tissue engineering. *ACS Applied Materials & Interfaces* (2016) 8:30797-30810. (IF-8.090, 20 citations).
11. Gupta P, Kumar M, **Bhardwaj N**, Kumar JP, Krishnamurthy CS, Nandi SK, Mandal BB. Mimicking form and function of native small diameter vascular conduits using mulberry and non-mulberry patterned silk films. *ACS Applied Materials & Interfaces* (2016), 8: 15874–15888 (IF-8.090, 22 citations). (Research highlight featured in Nature India)
12. Kumar M, Jain D, **Bhardwaj N**, Gupta P, Nandi SK, Mandal BB. Native honeybee silk membrane: A potential matrix for tissue engineering and regenerative medicine. *RSC Advances*, (2016), 6: 54394 - 54403. (IF-2.936, 2 citations)
13. Gupta P, Kumar M, **Bhardwaj N**, Kumar JP, Krishnamurthy CS, Nandi SK, Mandal BB. Bioengineered silk vascular grafts for coronary artery bypass surgery. *European Cells and Materials* (2016), 31: 412. (IF-3.667)

14. Adhikary M, Gupta P, Kumar M, Jasmine S, **Bhardwaj N**, Chouhan D, Mandal BB. Hydroxyapatite-silk fiber-silk fibroin tri-composite scaffolds for bone tissue engineering. *European Cells and Materials* (2016) 31:18. (IF-3.667).
15. **Bhardwaj N**, Rajkhowa R, Wang X, Devi D. Milled non-mulberry silk fibroin microparticles as biomaterial for biomedical applications. *International Journal of Biological Macromolecules* (2015), 81:31-40. (IF-3.909, 15 citations)
16. **Bhardwaj N**, Sow WT, Devi D, Ng KW, Mandal BB, Cho NJ. Silk fibroin–keratin based 3D scaffolds as a dermal substitute for skin tissue engineering. *Integrative Biology* (2015), 7: 53-63. (IF-3.294, 75 citations) (Selected as Front Cover Page Article, HOT article 2015 and Most downloaded articles of Integrative Biology 2015)
17. **Bhardwaj N**, Devi D, Mandal BB. Tissue engineered cartilage: the crossroads of biomaterials, cells and stimulating factors. *Macromolecular Bioscience* (2015), 15: 157-182. (IF-3.392, 39 citations).
18. **Bhardwaj N** and Kundu SC. Chondrogenic differentiation of rat MSCs on porous scaffolds of silk fibroin/chitosan blends. *Biomaterials* (2012), 33: 2848-2857. (IF-8.80, 133 citations). (Research highlight featured in Nature India)
19. Kundu SC, Kundu B, Talukdar S, Bano S, Nayak S, Kundu J, Mandal BB, **Bhardwaj N**, Botlagunta M, Dash BC, Acharya C, Ghosh AK. Non-mulberry silk biopolymers. *Biopolymers* (2012), 97:455-67. (IF-1.990, 111 citations).
20. **Bhardwaj N**, Nguyen QT, Chen AC, Kaplan DL, Sah RL, Kundu SC. Potential of 3-D tissue constructs engineered from bovine chondrocyte / silk fibroin-chitosan for in vitro cartilage tissue engineering. *Biomaterials* (2011), 32: 5773-5781. (IF-8.80, 137 citations). (Research highlight featured in Nature India)
21. **Bhardwaj N** and Kundu SC. Silk fibroin protein and chitosan polyelectrolyte complex porous scaffolds for tissue engineering applications. *Carbohydrate polymers* (2011), 85: 325-333. (IF-5.15, 143 citations).

22. **Bhardwaj N**, Chakraborty S and Kundu SC. Freeze-gelled silk fibroin protein scaffolds for potential applications in soft tissue engineering. *International Journal of Biological Macromolecules* (2011), 49: 260-267. (IF-3.909, 40 citations).
23. **Bhardwaj N** and Kundu SC. Electrospinning: A fascinating fiber fabrication technique. *Biotechnology Advances* (2010), 28: 325-347. (IF-11.45, 2384 citations) (Most cited and downloaded articles of *Biotechnology Advances* and awarded Top cited Article “2009-2011”).

Book Chapters:

1. **Bhardwaj N***, Chouhan D, Mandal BB. 3D functional scaffolds for skin tissue engineering in “Functional Three-Dimensional Tissue Engineering Scaffolds: Materials, Technologies and Applications”. Edited by Y. Deng and J. Kuiper. **Woodhead Publisher (Elsevier), USA (2018)**, pp-345-365. (1 citation) (*Corresponding author).
2. Singh YP, Mehrotra S, Kumar JP, Bhunia BK, **Bhardwaj N**, Mandal BB. Tissue Engineering Therapies for Ocular Regeneration in Biomaterials & Nanotechnology for Tissue Engineering Edited by S. Swaminathan, K. Uma Maheswari and S. Anuradha. **CRC Press (Taylor and Francis Group), USA (2016)**, pp-173-197.
3. Nayak S, **Bhardwaj N**, Talukdar S, Kundu B, Bano S and Kundu SC. Biotechnology of the silk proteins challenges, approaches and applications in Biotechnology in Biopolymers: Developments, Applications & Challenging Areas, **iSmithers-Rapra Publication, UK (2012)** pp-371-393.

Abstracts and publications in conferences

1. Singh YP, Adhikary M, **Bhardwaj N**, Bhunia BK, Mehrotra S, Mandal BB. Bioinspired three dimensional construct with silk fiber reinforcement for regeneration of load bearing soft tissues. TERMIS-Americas Conference & Exhibition Charlotte, North Carolina, USA December 3–6, 2017, 23: 102. (Published in **Tissue Engineering Part A, IF-3.48**) POSTER
2. **Bhardwaj N**, Devi D, Mandal BB. Biomimetic silk fibroin/chondrocyte constructs of muga silkworm *Antheraea assamensis* for cartilage tissue engineering. International Conference on Biomaterials, Biodiagnostics, Tissue engineering, Drug Delivery and Regenerative Medicine (**Bi-TERM 2016**), April 15-17, 2016, Indian Institute of Technology Delhi (IIT Delhi). ORAL

3. Singh YP, **Bhardwaj N**, Mandal BB. Potential of agarose/silk fibroin blended hydrogel for *in vitro* cartilage tissue engineering. International Conference of Young Researchers on Advanced Materials (**IUMRS-ICYRAM 2016**), December 11-15, Indian Institute of Science, Bangalore, India. ORAL
4. Mehrotra S, **Bhardwaj N**, Nandi SK, Mandal BB. Biomimetic mulberry and non-mulberry silk sheets for cardiac patch applications. International Conference of Young Researchers on Advanced Materials (**IUMRS-ICYRAM 2016**), December 11-15, Indian Institute of Science, Bangalore, India. POSTER (**BEST POSTER AWARD**)
5. Gupta P, Kumar M, **Bhardwaj N**, Kumar PJ, Krishnamurthy CS, Nandi SK, Mandal BB. Bioengineered silk grafts for small diameter blood vessel replacement. International Conference on Biomaterials, Biodiagnostics, Tissue engineering, Drug Delivery and Regenerative Medicine (**Bi-TERM 2016**), April 15-17, 2016, Indian Institute of Technology Delhi (IIT Delhi). POSTER
6. Devi D, Talukdar B, Dutta S, Baruah RR, **Bhardwaj N**, Rajkhowa R, Wang X. Non Mulberry silk as non-textile materials. International Conference on Materials Science and Technology, March 1-4, 2016, University of Delhi. www.vbripress.com/icmtech, DOI: 10.5185/icmtech.2016. ORAL
7. Chakravarty S, **Bhardwaj N**, Mandal BB, Sarma NS. Explosive vapour detection using light weight and flexible carbon nanoparticles coated 3D macroporous composite silk scaffolds as green chemiresistor. Nanoparticle Assembly: From Fundamentals to Applications Faraday Discussion, IIT Bombay, India, Jan 7-9, 2016. (Organized by RSC) POSTER
8. Rajkhowa R, Kazemimostaghim M, **Bhardwaj N**, Allardyce BJ, Devi D, Wang X. Biocompatibility and drug binding and release properties of milled silk particles. 4th TERMIS World Congress Boston, Massachusetts, USA, September 8–11, 2015, 21: 404-405. (**Published in Tissue Engineering Part A, IF-3.48**) POSTER
9. Chakravarty S, **Bhardwaj N**, Mandal BB, Sarma NS. *B. mori* Silk as a versatile biodegradable material for next generation sensing applications. UGC-SAP National Seminar on Emerging Trends in Chemical Sciences 2015, Gauhati University, India, November 5-6, 2015. POSTER
10. Baruah RR, **Bhardwaj N**, Devi D. Fabrication of silk fibroin nanoparticles of *Antheraea assamesnsis* for biological applications. International Conference on Disease Biology and

Therapeutics (ICDBT-2014), Institute of Advanced Study in Science and Technology (IASST), Guwahati, 292, December 3-5, 2014. POSTER

11. **Bhardwaj N**, Devi D, Cho NJ, Mandal BB. Silk fibroin–keratin 3D scaffolds as a dermal substitute for skin tissue engineering. Tissue Engineering and Regenerative Medicine International Society Meeting (TERMIS-AP), October 23-26, 243, 2013, China. ORAL

12. **Bhardwaj N**, Nayak S, Kundu SC. Silk Proteins as Biomaterial for Tissue Engineering and Regenerative Medicine. International workshop on New Visions for Biomaterials and Regenerative Medicine, March,16-17, 2011, 15-19, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram, Kerala. ORAL

13. **Bhardwaj N**, Nguyen QT, Chen AC, Kaplan DL, Sah RL, Kundu SC. Silk fibroin/chitosan polyelectrolyte complex 3D tissue constructs for cartilage tissue engineering. Tissue Engineering and Regenerative Medicine International Society Meeting (TERMIS-AP), August 3-5, 49, 2011, Singapore. ORAL

14. Kundu SC, Acharya C, Dash R, Mandal BB, Kundu J, **Bhardwaj N**, Nayak S, Talukdar S, Dewan M, Kundu B. Non-mulberry Silk Proteins Advanced Natural Biomaterial for Tissue Engineering and Drug Delivery. Second TERMIS World Congress August 31-September 03, 2009, Seoul, Republic of Korea. ORAL

15. **Bhardwaj N**, Kundu SC. Preparation, characterization and *in vitro* evaluation of silk fibroin/chitosan blended 3-D scaffolds. International conference on Biomaterials and Tissue Engineering for Biotechnological Applications (BTEB 2008), November 22-24, 39, 2008, IIT Kharagpur, India. POSTER.

Member of Organizations:

- Tissue Engineering and Regenerative Medicine Society (**TERMIS**)
- Life member of Asian Polymer Association (**APA**)
- International Association of Advanced Materials (**IAAM**)

Reviewer for Journals:

- ACS Applied Materials and Interfaces (**IF-8.090**)
- Material Science and Engineering C (**IF-5.080**)

- Colloids and Surfaces B: Biointerfaces (IF-3.997)
- International Journal of Biological Macromolecules (IF-3.909)
- Journal of Physics D: Applied Physics (IF-2.373)
- Burns (IF-2.134)
- Biofabrication (IF-6.838)
- Advanced Healthcare Materials (IF-5.609)

Collaborators:

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