

Biomedical Technologies and Innovation Doctoral Programme (BIOTIN)



Title of the PhD Project	Machine learning assisted predictive design of biomineralizing peptides for tissue regeneration
Acronym	BioMInt
Research Fields of the Project	Materials Science, Molecular Engineering, Biochemistry, Data Science, Dentistry
Keywords	Biomaterialization, Molecular Biomimetics, Tissue Regeneration, Artificial Intelligence, Peptide Therapeutics
Host Institution, Department and Campus Location	Izmir Institute of Technology, Bioengineering Department, Urla/Izmir
PhD Awarding Institution and Graduate Programme	Izmir Institute of Technology, Graduate School, PhD in Bioengineering
Name and Affiliation of Main Supervisor	Asst. Prof. Deniz Yucesoy (IZTECH)
Name and Affiliation of Co-supervisors	Asst. Prof. Işıl Öz (IZTECH) Assoc. Prof. Duygu Ege (BOUN)
Research Environment and Infrastructure	<p>IZTECH has been distinguished as "one of the Top 5 Research Universities" in Turkey. Faculty of Engineering hosts more than 100 research labs in diverse fields, including biomimetics, advanced manufacturing (Dept. of Bioengineering), deep learning, artificial intelligence, optimization, and search (Dept. of Computer Engineering), as well as high-throughput (HTP) experimentation facilities providing an excellent base and vibrant research environment for the project. Yucesoy Research Group has required facilities for the experimental selection and characterization of the mineralizing peptides, computational resources for constructing predictive design platforms, and HTP validation tools. https://yucesoylab.com/</p> <p>Institute of Biomedical Engineering (BOUN) has dedicated facilities for the production and in-depth characterization of the biomaterials, including Fourier Infra-red Spectroscopy (FTIR) (Perkin Elmer), X-Ray Diffraction Spectroscopy (XRD) (Rikagu), X-ray Photoelectron Spectroscopy (XPS) (Thermo Scientific), and Scanning Electron Microscopy (SEM) (Phillips-FEI XL-30).</p> <p>In addition to secondment institutions listed below, Yucesoy Research Group has a strong academic and industry network, including leading dental manufacturing companies from the US and Europe, which will provide the R&D and manufacturing</p>



	facilities access and necessary expert training in product design, validation, and benchmarking.
Scientific Context of the Project	<p>Demineralization, the loss of tooth minerals, is the root cause of many dental diseases. With a better understanding of the biology of dental tissues and tooth development, the regenerative strategies to treat lost or damaged dental tissues have become very attractive. However, the clinical adaptation of regenerative therapeutics has remained limited. The obstacle chiefly stems from incomplete knowledge of the functional proteins or, if known, simply the inadequate availability of these complex proteins. Deriving short peptides that mimic the functionalities of their protein counterparts represent a practical solution to accelerate the adaptation of regenerative therapeutics in dental health care. Proposed herein is developing an ML-based predictive peptide design platform called "Biomineralization Intelligence, BioMInt" using the peptide (big) data sets acquired via deep-directed evolution and custom high-throughput (HTP) assays. The accelerated design of (re)mineralizing peptides through this platform will enable the development of a molecular toolkit called for targeted regeneration and repair of dental tissues. Aligned with the current vision of tele-dentistry that aims to adapt methodologies to generate big data and tools to enable fast-track discoveries with healthcare delivery, this study marks the onset of implementing ML and HTP screening methods in dental research. Successful completion of this project will result in a line of preventive oral care products with the long-term vision of complete tooth regeneration.</p>
Brief Workplan	<p>Month 1-18: Peptide Screening via DDE</p> <p>Month 7-19: Data Analysis & DOE</p> <p>Month 13-30: Design of ML Platform</p> <p>Month 13-42: HTP Screening Validation</p> <p>Month 25-48: Formulation Development & Prototyping</p>
Innovative Aspects of the Project	<p>There have been considerable attempts, both commercially and scientifically, to develop therapies that boost remineralization, but none have had clinical success so far. This project will lay the groundwork for biomimetic dental tissue repair with a long-term goal of developing a universal hard tissue regeneration therapy using algorithms (BioMInt) that enable accelerated discovery of tissue-specific (enamel, cementum, etc.) therapeutics to eventually establish a molecular toolkit for complete tissue regeneration. Once developed successfully, the biomimetic remineralization therapy is anticipated to be a game changer in dentistry and preventive daily oral healthcare. No other works have aimed to address hard tissue regeneration in the fields of ML and HTP experimentation. This universal design algorithm will significantly impact peptide/protein therapeutics research. In addition, the interdisciplinary methodology developed herein will address big gaps in the scientific literature, including (1) Development of novel high-throughput therapeutic design protocols and (2) Design of ML-based predictive peptide design platform, BioMInt, trained with the dataset acquired from HTP experimentation.</p>

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Training Opportunities of the Project	<p>The blend of Yucesoy-Öz-Ege mentorship will equip the researcher with joint technical skills to develop BioMInt technology. Particularly, the PhD candidate will be trained in a range of statistical tools for the design of experiments (DoE), ML and data analysis methods such as pattern recognition tools, neural networks, data-pipeline design (Yucesoy & Öz) as well as HTP experimentation (Yucesoy), thereby boosting and diversifying their research expertise. Working closely with the industrial secondment mentor, candidate will acquire expert product design, validation, and benchmarking training. In addition, the technology transfer, IPR and commercialization training the researcher will receive from Atmosphere TTO will enhance their entrepreneurial skills which will be further facilitated by engaging with industry network towards the full-scale development and commercialization of the translational dental care products.</p>
Interdisciplinary Aspects	<p>During this translational project converging life sciences, materials science, dentistry, and data science, the researcher will transcend into HTP experimentation and data science and eventually into the development of a new line of dental care products.</p> <p>Several aspects make the planned interdisciplinary research stand out, including (1) Connecting the expertise of Prof. Öz & Prof. Yucesoy in data science and with that of Prof. Yucesoy in HTP experimentation and Prof. Ege in materials characterization to study a novel research field Deep Directed Evolution for HTP Therapeutics Design, (2) Harnessing the expertise of leading industry experts in oral care products to translate findings into therapeutic products, and (3) Building a strong academic and industry network revolving around Dental Care in the EU and beyond.</p>
Intersectoral Mobility <input checked="" type="checkbox"/> Short Visit <input type="checkbox"/> Secondment	<p><i>Host: SIEMENS Healthineers (TR)</i></p> <p><i>Context of Mobility: Innovation management, Entrepreneurship, Prototyping, IP rights, 3D modelling</i></p>
Intersectoral Mobility <input checked="" type="checkbox"/> Short Visit <input type="checkbox"/> Secondment	<p><i>Host: LetGen Biotech</i></p> <p><i>Context of Mobility: Training on library preparation & next-generation sequencing</i></p>
Intersectoral Mobility <input checked="" type="checkbox"/> Short Visit <input type="checkbox"/> Secondment	<p><i>Host: Istanbul Health Industry Cluster (ISEK)</i></p> <p><i>Context of Mobility: Entrepreneurship Training, Thematic Pre-incubation Program</i></p>

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<p>International Academic Secondment</p>	<p><i>Host Supervisor: Osman Ünsal</i></p> <p><i>Host Institution: Barcelona Supercomputing Center, Barcelona, Spain</i></p> <p><i>Host Department: Computer Sciences - Computer Architecture for Parallel Paradigms</i></p> <p><i>Duration: 6 months</i></p> <p><i>Estimated Time of Mobility: 2nd year of the PhD</i></p> <p>OR</p> <p><i>Host Supervisor: Marisa Gil</i></p> <p><i>Host Institution: Polytechnic University of Catalonia, Barcelona, Spain</i></p> <p><i>Host Department: Computer Architecture Department</i></p> <p><i>Duration: 6 months</i></p> <p><i>Estimated Time of Mobility: 2nd year of the PhD</i></p>												
<p>Main Supervisor</p>													
<p>Brief CV</p>	<p>Asst. Prof. Deniz Yucesoy</p> <p>E-mail: denizyucesoy@iyte.edu.tr</p> <p>ACADEMIC DEGREES</p> <table border="0"> <tr> <td>Ph.D.</td> <td>Materials Science and Engineering</td> <td>University of Washington, US</td> <td>2018</td> </tr> <tr> <td>M.Sc.</td> <td>Materials Science and Engineering</td> <td>University of Washington, US</td> <td>2014</td> </tr> <tr> <td>B.Sc.</td> <td>Molecular Biology & Genetics</td> <td>Izmir Institute of Technology</td> <td>2009</td> </tr> </table> <p>ResearchGate: https://www.researchgate.net/profile/Deniz-Yucesoy https://orcid.org/0000-0002-9590-3178</p>	Ph.D.	Materials Science and Engineering	University of Washington, US	2018	M.Sc.	Materials Science and Engineering	University of Washington, US	2014	B.Sc.	Molecular Biology & Genetics	Izmir Institute of Technology	2009
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<p>Brief CV</p>	<p>Asst. Prof. Işıl Öz</p> <p>E-mail: isiloz@iyte.edu.tr</p> <p>ACADEMIC DEGREES</p> <table border="0"> <tr> <td>Ph.D.</td> <td>Computer Engineering</td> <td>Boğaziçi University, Turkey</td> <td>2013</td> </tr> <tr> <td>M.Sc.</td> <td>Computer Engineering</td> <td>Marmara University, Turkey</td> <td>2008</td> </tr> <tr> <td>B.Sc.</td> <td>Computer Engineering</td> <td>Marmara University, Turkey</td> <td>2004</td> </tr> </table> <p>Google Scholar: https://scholar.google.com/citations?user=Jber3GMAAAJ&hl https://orcid.org/0000-0002-8310-1143</p>	Ph.D.	Computer Engineering	Boğaziçi University, Turkey	2013	M.Sc.	Computer Engineering	Marmara University, Turkey	2008	B.Sc.	Computer Engineering	Marmara University, Turkey	2004
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<p>Brief CV</p>	<p>Assoc. Prof. Duygu Ege</p> <p>E-mail: duygu.ege@boun.edu.tr</p> <p>ACADEMIC DEGREES</p> <table border="0"> <tr> <td>Ph.D.</td> <td>Medical Material</td> <td>University of Cambridge, UK</td> <td>2013</td> </tr> <tr> <td>M.Eng.</td> <td>Materials Science and Engineering</td> <td>Imperial College, UK</td> <td>2009</td> </tr> <tr> <td>B.Sc.</td> <td>Materials Science and Engineering</td> <td>Imperial College, UK</td> <td>2008</td> </tr> </table> <p>Google Scholar: https://scholar.google.com/citations?user=rrnTjdIAAAJ&hl https://orcid.org/0000-0002-9922-6995</p>	Ph.D.	Medical Material	University of Cambridge, UK	2013	M.Eng.	Materials Science and Engineering	Imperial College, UK	2009	B.Sc.	Materials Science and Engineering	Imperial College, UK	2008
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