



# PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

**THEMATIC Research Field: UNRAVELING DAMAGE EVOLUTION IN BIO-INSPIRED MATERIALS: AN INTERDISCIPLINARY MULTI-SCALE STUDY FOR ENHANCED MECHANICAL DESIGN**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1400.0**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## Context of the research activity

### Motivation and objectives of the research in this field

The investigation of damage and fracture mechanisms in bioinspired materials is a rapidly growing area of study that aims to understand how these complex materials can resist and recover from various forms of damage, including mechanical stress, and environmental factors. The research is motivated by diverse objectives, such as the development of more sustainable and resilient materials for use in medicine, mechanical and material engineering, as well as the achievement of a deeper understanding of the fundamental principles governing biological systems. The study seeks to identify multi-scale structural and functional features that allow bioinspired materials to withstand damage and to design and realize novel materials and techniques that can mimic these properties. The ultimate objective of this research is to design and produce materials that can resist damage and adapt to different conditions, thereby improving our quality of life and contributing to advances in various scientific and engineering fields.

### Methods and techniques that will be developed and used to carry out the research

This research requires a multi-faceted range of methods and techniques to investigate multi-scale damage phenomena and to translate this understanding to the design of novel structures, including:

1. Imaging techniques: micro-computed tomography, synchrotron analyses, scanning electron microscopy are



	<p>especially useful for identifying microstructural features that may contribute to a material resilience;</p> <p>2. 3D printing and 3D bio-printing for complex structure design;</p> <p>3. Multi-scale mechanical testing to study material mechanical properties, including its strength, toughness, and elasticity;</p> <p>4. Computational modeling, to simulate damage evolution, weakening and toughening phenomena at the multi-scale, including extended finite element (XFEM) strategies to model fracture progression;</p> <p>5. Image analysis, adopting effective artificial intelligence-based tools for the post-processing of large size datasets, such as high-resolution imaging.</p>
Educational objectives	<p>This cutting-edge research perspective on damage-tolerant bio-inspired materials is a unique opportunity for PhD students to:</p> <p>1. Deepen the multi-scale structure and properties of biological and bio-inspired materials, as well as the principles that govern their damage response;</p> <p>2. Exploit a plethora of different methods and techniques, including advanced imaging techniques, mechanical testing, and computational modeling;</p> <p>3. Develop critical thinking, problem-solving skills and foster innovation and creativity by guiding PhD students in the design of novel bio-inspired structures with enhanced mechanical properties;</p> <p>4. Set up interdisciplinary collaboration between students and faculty in different fields, such as biology, physics, mechanical and material engineering.</p>
Job opportunities	<p>Our last survey on MeccPhD Doctorates highlighted a <b>100% employment rate</b> within the first year and a <b>35% higher salary</b>, compared to Master of Science holders in the same field.</p> <p>Further Institutions cooperating in the research are:</p> <ul style="list-style-type: none"> <li>- MIT, Boston (<i>Laboratory for Atomistic and Molecular Mechanics, development of artificial intelligence-based solutions</i>);</li> <li>- TU Delft (<i>bio-inspired material design</i>);</li> </ul>



	<ul style="list-style-type: none"> <li>- Galeazzi Orthopaedic Institute (<i>biological tissues</i>);</li> <li>- Elettra synchrotron (<i>high-resolution real-time imaging of damage</i>).</li> </ul>
<b>Composition of the research group</b>	1 Full Professors 0 Associated Professors 1 Assistant Professors 2 PhD Students
<b>Name of the research directors</b>	Prof. Laura Maria Vergani

<b>Contacts</b>
<p>Phone: +39 022399249 Email: laura.vergani@polimi.it</p> <p>For questions about scholarship/support phd-dmec@polimi.it</p>

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	700.0 €
<b>By number of months</b>	6

<b>Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information</b>
<p>Financial aid is available for all PhD candidates (purchase of study books and materials, funding for participation in courses, summer schools, workshops and conferences) for a total amount of euro 5.707,13.</p> <p>Our candidates are strongly encouraged to spend a research period abroad, joining high-level research groups in the specific PhD research topic, selected in agreement with the Supervisor. An increase in the scholarship will be applied for periods up to 6 months (approx. 700 euro/month - net amount).</p> <p>Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.</p>