Prot. n. 0405367 del 20/12/2024 - Provvedimenti dirigenziali 7622/2024

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA | AREA RICERCA

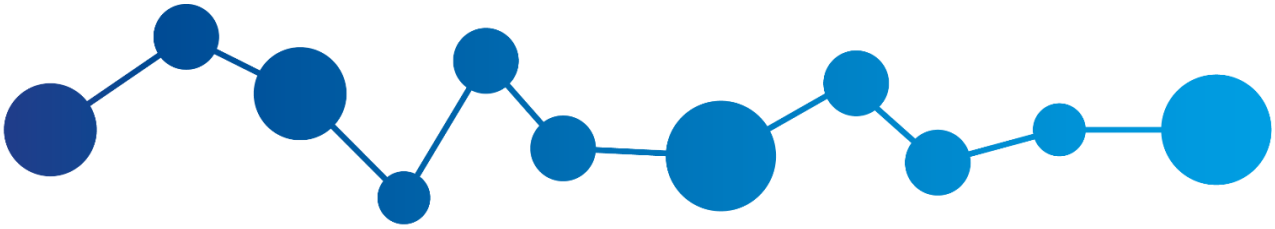
FutureData4EU
Training Future Big Data Experts for Europe

**AVVISO DI SELEZIONE PER L'AMMISSIONE DI 10 POSIZIONI DI DOTTORATO**

**FINANZIATE CON ASSEGNO DI RICERCA**

**41° CICLO - a.a. 2025/2026**

**PROGRAMMA DOTTORALE MARIE SKŁODOWSKA-CURIE ACTIONS – COFUND**



# FutureData4EU

## Training Future Big Data Experts for Europe

**Apertura del bando: 20 dicembre 2024**

**Termine per la presentazione delle candidature: 10 marzo 2025**

**ore 14.00 CEST (orario italiano)**

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA | AREA RICERCA

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## Premessa

Il progetto "*FutureData4EU - Training Future Big Data Experts for Europe*" è finanziato nell'ambito del bando "*Marie Sklodowska-Curie Actions Co-funding of regional, national and international programmes - HORIZON-MSCA-2022-COFUND-01-01*" del Programma Quadro di Ricerca e Innovazione dell'Unione Europea Horizon Europe. Il progetto, della durata di 60 mesi, prevede l'attivazione di un programma dottorale che comprende posizioni di dottorato presso l'Ateneo di Bologna e presso le altre università operanti sul territorio della regione Emilia-Romagna con il ruolo di *Implementing Partners*: le Università di Ferrara, di Modena e Reggio Emilia, di Parma, il Polo territoriale di Piacenza del Politecnico di Milano e il Campus di Piacenza dell'Università Cattolica del Sacro Cuore.

FutureData4EU intende offrire ai ricercatori e alle ricercatrici nella fase iniziale della loro carriera, ovvero che non abbiano già ottenuto il titolo di dottorato, un programma di formazione innovativo con carattere fortemente internazionale, intersettoriale e interdisciplinare, attraverso la mobilità transnazionale e lo sviluppo di carriera. FutureData4EU è quindi aperto alla partecipazione di ricercatrici e ricercatori provenienti da tutto il mondo. Intende contribuire a rafforzare la collaborazione col settore non accademico, permettendo ai giovani dottorandi di sviluppare la propria professionalità negli ecosistemi socioeconomici locali, regionali e/o nazionali nell'ambito delle tematiche dei Big Data.

La gestione dei Big Data, anche attraverso capacità di calcolo ad alte prestazioni, è infatti considerata la ricchezza della nuova economia della conoscenza. Fornisce opportunità di ricerca e innovazione senza precedenti in vari settori applicativi, dalle simulazioni climatiche e geofisiche alla salute, dalla mobilità e logistica ai beni culturali e multimediali, dal cambiamento digitale nei sistemi di produzione ai nuovi materiali e all'analisi finanziaria. Le infrastrutture digitali, l'architettura di calcolo ad alte prestazioni, l'architettura cluster su larga scala e l'infrastruttura di rete a banda ultra-larga subiranno un'enorme innovazione nei prossimi anni.

In Italia, il 70% della capacità di calcolo e storage nazionale si trova nella regione Emilia-Romagna. Questo soprattutto grazie alle strutture di supercalcolo presenti presso CINECA (uno degli *European Large-Scale Facilities*, fondatore di PRACE - Partnership for Advanced Computing in Europe) e INFN (Istituto Nazionale di Fisica Nucleare) e grazie alla realizzazione del supercomputer Leonardo, sostenuto dall'*EuroHPC Joint Undertaking*. CINECA e INFN sono partner del progetto FutureData4EU, che beneficia inoltre del supporto della Regione Emilia-Romagna, creando un vivace ecosistema di ricerca e innovazione, che fa dell'Emilia-Romagna una vera e propria *data valley* e il luogo ideale in cui sviluppare le proprie competenze.

Il presente bando di selezione è pubblicato sulla pagina web FutureData4EU (https://site.unibo.it/futuredata4eu/en). Eventuali aggiunte, modifiche o aggiornamenti saranno pubblicati su tale pagina web. A tutti gli effetti, il presente avviso di selezione costituisce un avviso ufficiale.

# Art. 1. Descrizione del programma

## 1.1. Obiettivi

Attraverso il programma di Dottorato FutureData4EU verrà formata una nuova generazione di ricercatori con competenze trasversali e interdisciplinari, sostenendone la carriera e fornendo loro le competenze necessarie alla collaborazione con organizzazioni del settore accademico e industriale, contando su un ampio network di collaborazioni con i Partner Associati coinvolti nel progetto che comprendono prestigiose realtà industriali, eccellenti centri di ricerca e infrastrutture di ricerca nazionali e internazionali, in ambito Big Data.

Il programma offre una combinazione innovativa di formazione, ricerca, e sviluppo di competenze trasversali nell'ambito Big Data. I talenti internazionali che verranno reclutati avranno l'opportunità di formarsi sviluppando progetti di ricerca e innovazione in un ampio spettro di aree tematiche in cui trovano applicazione i Big Data: salute, cultura, sicurezza, industria, aerospazio, clima, energia, agricoltura, risorse naturali e ambiente.

## 1.2. Programma

Il Programma FutureData4EU prevede l'attivazione di 53 posizioni di dottorato nell'ambito di 47 corsi di dottorato attivi nelle sei università emiliano-romagnole, articolate su 7 aree tematiche: Health; Culture, Creativity and Inclusive Society; Civil Security for Society; Digital, Industry and Space; Climate, Energy and Mobility; Food, Bioeconomy, Natural Resources, Agriculture and Environment; Enabling Technologies.

Un primo avviso di selezione pubblicato nel giugno 2024 ha consentito di selezionare candidati per 43 delle 53 posizioni disponibili. Il presente avviso di selezione offre alle candidate e ai candidati provenienti da tutto il mondo un totale di 10 posizioni di dottorato della durata di 36 mesi, in altrettanti corsi di dottorato, nelle seguenti aree tematiche in cui trovano applicazione i Big Data (Allegato 1 - Schede di Dottorato e temi di ricerca FutureData4EU):

1. Health;
2. Culture, Creativity and Inclusive Society;
3. Civil Security for Society;

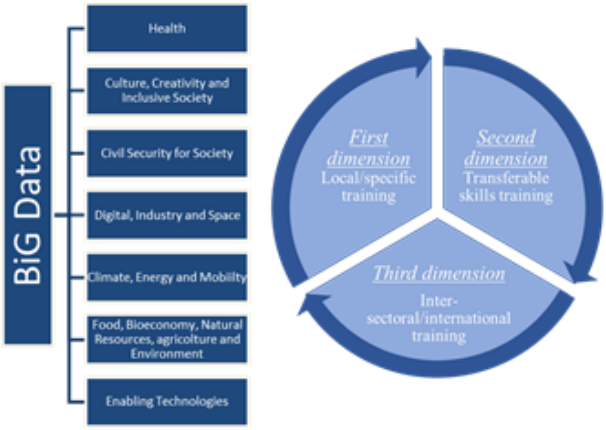
4. Digital, Industry and Space;
5. Climate, Energy and Mobility;
6. Enabling Technologies

Le candidate e i candidati devono possedere i requisiti per poter essere ammessi agli studi di terzo ciclo (dottorato) e devono soddisfare i requisiti previsti dal bando "*Marie Sklodowska-Curie Actions Co-funding of regional, national and international programmes - HORIZON-MSCA-2022-COFUND-01-01*", così come riportati nel presente avviso di selezione (Art. 2 Requisiti di ammissione). La procedura di selezione sarà aperta, trasparente e basata sul merito (Art. 4 Processo di selezione). Con le candidate e i candidati che saranno risultati vincitrici e vincitori verrà stipulato un contratto di assegno di ricerca della durata di 36 mesi.

Ciascun/a candidato/a dovrà scegliere 1 area tematica, indicando, a mero titolo informativo, l'ordine di interesse per ciascuna posizione di dottorato disponibile per quell'area (Allegato 1 - Schede di Dottorato e temi di ricerca FutureData4EU). Al fine dell'assegnazione delle posizioni di dottorato a bando, la commissione selezionatrice (Art. 5 Commissione di valutazione) assegnerà a ciascun/a candidato/a, a suo insindacabile giudizio, una valutazione di idoneità per una o più posizioni. In caso di rinuncia espressa o tacita alla posizione assegnata, essa sarà proposta alle candidate e ai candidati idonei secondo l'ordine della graduatoria (Art. 6 Graduatorie).

La formazione offerta all'interno di FutureData4EU si declina in tre dimensioni:

1. La prima riguarda i domini disciplinari e multidisciplinari dei progetti di ricerca, attraverso lo sviluppo di conoscenze, metodologie e competenze specifiche, che verranno erogate sotto forma di corsi, seminari e workshop.
2. La seconda riguarderà le competenze trasversali, quali la capacità di scrivere e presentare articoli scientifici e relazioni in seminari, workshop e conferenze; come gestire i dati della ricerca e l'open science; come depositare brevetti e gestire aspetti legati alla proprietà intellettuale; nozioni sul trasferimento tecnologico e l'imprenditorialità; come fare scouting delle opportunità di finanziamento per la ricerca e come predisporre le domande di finanziamento. La formazione sulle competenze trasversali sarà fornita sia a livello locale che durante i periodi di distacco internazionali e/o intersettoriali (*secondment*).




3. La terza dimensione prevede periodi di *secondment* internazionali/intersettoriali. Sono previsti due periodi di *secondment*, di cui uno presso un ente accademico di livello internazionale, e uno presso un ente non accademico, favorendo una contaminazione intersettoriale.

## Art. 2. Requisiti di ammissione

Alla data di chiusura del bando le candidate e i candidati di qualsiasi nazionalità, a pena di esclusione, devono soddisfare i seguenti criteri:

- ✓ **Mobilità**. Le candidate e i candidati non devono aver risieduto o aver svolto la loro attività principale (lavoro, studio, ecc.) in Italia per più di 12 mesi nei 3 anni immediatamente precedenti la data di scadenza del presente bando di selezione, ossia dal 11 marzo 2022 al 10 marzo 2025. Non viene considerato il tempo trascorso dalla candidata o dal candidato per lo svolgimento del servizio nazionale obbligatorio o per la procedura necessaria a ottenere lo status di rifugiato ai sensi della Convenzione di Ginevra.
- ✓ **Titoli**. Le candidate e i candidati devono essere in possesso di un titolo accademico di secondo livello (es. laurea magistrale o specialistica, laurea dell'ordinamento previgente, analogo titolo rilasciato dalle istituzioni facenti parte del comparto AFAM Alta Formazione Artistica e Musicale).

  I titoli conseguiti in Paesi esteri devono essere riconosciuti equivalenti a un titolo accademico di secondo livello e idonei all'ammissione al dottorato di ricerca nel Paese di rilascio.

  Le candidate e i candidati che non possiedono i requisiti di cui sopra alla data di scadenza del presente bando sono ammessi con riserva, ma il titolo di studio necessario per l'accesso ai corsi di dottorato dovrà essere conseguito e certificato entro il 26/05/2025. Più precisamente, il 26/05/2025 è il termine entro il quale fare pervenire alla casella di posta cofund@unibo.it il certificato di conseguimento del titolo di studio necessario per l'accesso ai corsi di dottorato, pena la decadenza.

  Quanti abbiano presentato un titolo di accesso al dottorato conseguito in Paesi esteri (dell'Unione Europea - EU o extra-EU) e non abbiano fornito in sede di presentazione della domanda di

ammissione un documento utile ai fini della dichiarazione di equivalenza del titolo di secondo livello conseguito (es. *Diploma Supplement*, Dichiarazione di Valore in loco rilasciata dalle Autorità diplomatiche italiane nel Paese in cui è stato conseguito il titolo, attestazione di autenticità e comparabilità rilasciata da centri come ENIC-NARIC) saranno ammessi con riserva alla procedura selettiva, ma in ogni caso dovranno consegnare il suddetto documento utile ai fini della dichiarazione di autenticità ed equivalenza del titolo di secondo livello conseguito, a pena di decadenza, entro il 15 settembre 2025.

- ✓ ***Doctoral Candidate stage***. Le candidate e i candidati non devono avere già conseguito un titolo di dottorato.

Non sono ammessi alla selezione le candidate e i candidati che:

- risultino personale di ruolo degli atenei e degli enti di cui all'art. 22 comma 1 della Legge 30 dicembre 2010, n. 240 (di seguito L. 240/2010);
- abbiano un grado di parentela o di affinità fino al quarto grado compreso con un professore appartenente al dipartimento o alla struttura che effettua la proposta di attivazione del contratto, ovvero con il Rettore, il Direttore Generale o un componente del Consiglio di Amministrazione dell'Ateneo;
- abbiano avuto contratti in qualità di assegnista di ricerca e di ricercatore a tempo determinato ai sensi degli artt. 22 e 24 della Legge 240/2010 presso l'Ateneo di Bologna o presso altri Atenei italiani, statali, non statali o telematici, nonché gli enti di cui al comma 1 dell'art. 22 della Legge 240/2010 per un periodo che, sommato alla durata prevista dal contratto messo a bando, superi complessivamente i 12 anni, anche non continuativi. Ai fini della durata dei predetti rapporti non rilevano i periodi trascorsi in aspettativa per maternità o per motivi di salute secondo la normativa vigente.

## Art. 3. Domanda di ammissione

### 3.1. Procedura di presentazione della domanda di ammissione

La domanda di ammissione alla selezione deve essere inoltrata utilizzando esclusivamente l'apposita procedura resa disponibile all'indirizzo web https://studenti.unibo.it (piattaforma Studenti Online).

La scadenza di presentazione della domanda è il 10 marzo 2025, ore 14.00 (CEST ora italiana).

Per essere considerata ammissibile, la domanda di ammissione deve essere:

- Inviata prima della scadenza utilizzando la procedura informatizzata per la presentazione delle proposte accedendo alla piattaforma Studenti Online. Ciascun allegato deve essere caricato in formato pdf.
- Completa di tutta la documentazione richiesta (3.2 Documenti da allegare alla domanda di ammissione).

L'impossibilità di rispettare uno dei requisiti di cui all'Art. 1 Requisiti di ammissione sarà motivo di esclusione in qualsiasi momento, durante la procedura di selezione o alla firma del contratto.

Non saranno accettate candidature presentate con modalità diverse da quelle indicate.

Il presente avviso di selezione, i suoi allegati e ogni documento rilevante per la domanda di ammissione sono disponibili alla pagina web FutureData4EU (https://site.unibo.it/futuredata4eu/en).

### 3.2. Documenti da allegare alla domanda di ammissione

Nella procedura online per la domanda di ammissione, le candidate e i candidati dovranno allegare i seguenti documenti:

| | **DOCUMENTI RICHIESTI** | **DESCRIZIONE** |
|---|---|---|
| **a)** | **Documento di riconoscimento con foto in corso di validità** | Scansione fronte retro. |
| **b)** | **Attestazione del conseguimento di ciascun titolo di studio universitario posseduto, di secondo livello**, indicante:<br><br>Università che ha rilasciato il titolo<br>Tipologia di laurea (magistrale, magistrale a ciclo unico, vecchio ordinamento ecc.)<br>Denominazione del corso di laurea<br>Classe di laurea (solo per i titoli conseguiti in Italia)<br>Data di conseguimento del titolo<br>Voto finale<br>Elenco e voto degli esami sostenuti con indicazione dei CFU, se previsti nel sistema universitario in cui è stato conseguito il titolo. | Tipo di attestazione, per chi ha conseguito il titolo in:<br><br>**1. Università pubbliche italiane**:<br>- autocertificazione, datata e firmata, del conseguimento della Laurea magistrale o vecchio ordinamento;<br>**2. Università di Stati europei o extra-europei**:<br>- il certificato di laurea di secondo livello originale con indicazione della data di conseguimento del titolo e il voto finale;<br>- il certificato *transcript of records* del titolo di secondo livello, completo della lista degli esami sostenuti e dei voti ottenuti (in lingua inglese); |

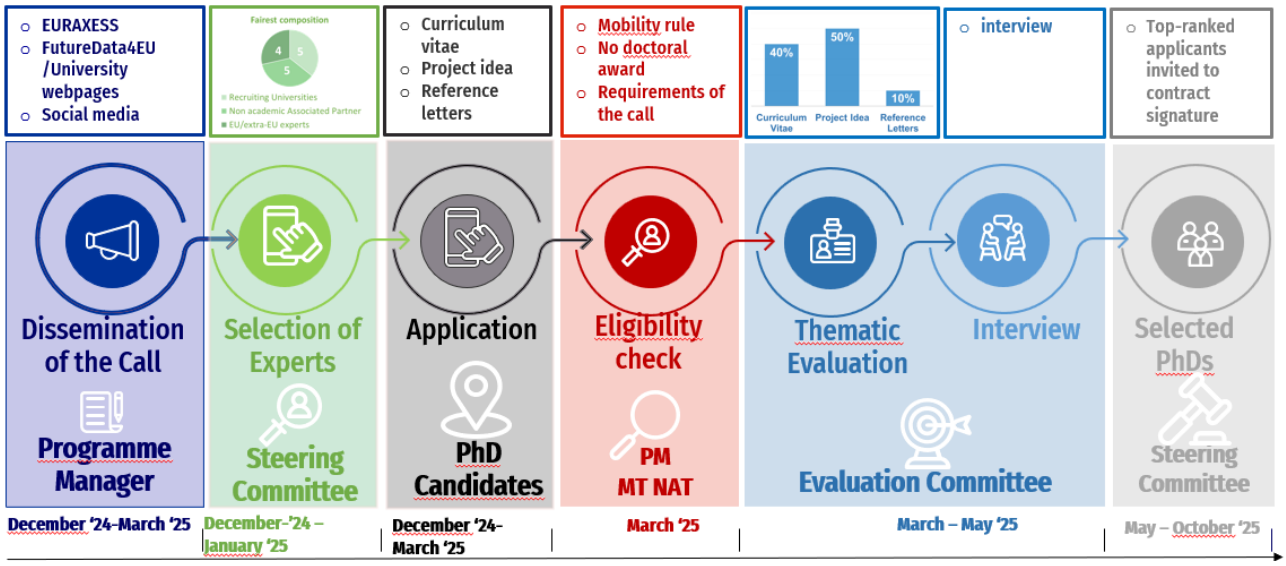
| | | |
|---|---|---|
| | *Per quanti, alla data di presentazione della candidatura, non possiedono il titolo di studio di secondo livello:*<br><br>**il certificato *transcript of records* del titolo di secondo livello** completo della lista degli esami sostenuti e dei voti ottenuti (in lingua inglese). | - se già disponibile, il documento utile ai fini della dichiarazione di equivalenza del titolo (es. *Diploma Supplement*, Dichiarazione di Valore in loco rilasciata dalle Autorità diplomatiche italiane nel Paese in cui è stato conseguito il titolo, attestazione di autenticità e comparabilità rilasciata da centri come ENIC-NARIC) (in lingua inglese). Si ricorda che in ogni caso tale documento deve essere consegnato, a pena decadenza, entro il 15/09/2025.<br><br>**3. Università private italiane**: in alternativa al certificato, è possibile allegare l'autocertificazione completa di tutti i dati richiesti, oppure il *Diploma Supplement*.<br><br>Tipo di attestazione, per chi non ha ancora conseguito il titolo di secondo livello:<br><br>- il certificato *transcript of records* del titolo di secondo livello completo della lista degli esami sostenuti e dei voti ottenuti (in lingua inglese). |
| **c)** | **Documento attestante la scelta dell'area tematica e l'ordine di interesse per ciascuna posizione di dottorato disponibile per l'area** | Pdf generato dal sistema Form On Line (FOL) accessibile all'indirizzo https://fol.unibo.it/futuredata4eu. |
| **d)** | **Curriculum Vitae in lingua inglese** | Si raccomanda di utilizzare il template di CV disponibile nel sito web del progetto. |
| **e)** | **Progetto di ricerca** | Da redigere<br><br>- in lingua inglese;<br>- utilizzando il modello disponibile sul sito web FuturaData4EU (https://site.unibo.it/futuredata4eu/en);<br>- di lunghezza massima di tre (3) pagine ad |

| | | |
|---|---|---|
| | | esclusione di eventuali grafici o immagini (ci si riserva di non valutare le pagine eccedenti).<br><br>Il progetto di ricerca deve contenere: il titolo del progetto; l'indicazione del tema di ricerca scelto tra quelli previsti; l'idea progettuale, gli obiettivi, la metodologia della ricerca proposta; l'attinenza del progetto di ricerca proposto con le competenze possedute, in relazione anche a quanto previsto nelle singole posizioni a bando. |
| **f)** | **Max 3 lettere di referenza in lingua inglese** | Le lettere di referenza saranno oggetto di valutazione. |
| **g)** | **Altri documenti valutabili** | Ulteriori documenti che il candidato ritiene utile fornire ai fini della valutazione, in relazione alle posizioni disponibili (Allegato 1 - Schede di Dottorato e temi di ricerca FutureData4EU). |
| **h)** | *Per quanti vogliano avvalersi di adattamenti per la prova di ammissione*<br><br>**Modulo di richiesta adattamenti e certificazione specialistica necessaria** | Per maggiori informazioni sugli adattamenti e sulla documentazione da allegare si veda la sezione 4.3 Candidate e candidati con disabilità o disturbi specifici dell'apprendimento (DSA) del presente bando. |

# Art. 4. Processo di selezione

## 4.1. Fasi della selezione

Di seguito è riportato un calendario indicativo del processo di selezione.




Eventuali ritardi o comunicazioni relative al processo generale saranno comunicati attraverso il sito web FutureData4EU (https://site.unibo.it/futuredata4eu/en).

Il processo di selezione programmato, coerente con i principi e i requisiti della Carta europea dei ricercatori, del Codice di condotta per l'assunzione dei ricercatori e della Strategia delle Risorse Umane per i Ricercatori - HRS4R, rispetterà i principi di equità e uguaglianza, evitando qualsiasi forma di discriminazione basata sul genere, età, etnia, origine nazionale o sociale, religione o credenze, orientamento sessuale, lingua, disabilità, opinione politica, condizione sociale o economica o nazionalità, in linea con i principi espressi da tutte le Università coinvolte nella selezione.

Il processo di selezione completo è composto da quattro fasi. I risultati di ciascuna fase di valutazione saranno pubblicati in forma anonima sul sito web di FutureData4EU non appena il processo sarà concluso, e le candidate e i candidati saranno informate/i della pubblicazione dei risultati via e-mail inviata dall'indirizzo cofund@unibo.it esclusivamente all'indirizzo di posta istituzionale nome.cognome@studio.unibo.it assegnato a ciascun candidato/a al momento della presentazione della domanda di ammissione.

- ✓ **FASE 1) Controllo di ammissibilità**. Il controllo di ammissibilità sarà effettuato dal *Programme Manager* (PM) congiuntamente al *Project Management Team* (MT) e al *Network Administrative Team* (NAT). Durante questa fase potrebbero essere richiesti chiarimenti o integrazioni ai documenti già presentati dalle candidate e dai candidati attraverso l'indirizzo di posta istituzionale nome.cognome@studio.unibo.it assegnata a ciascun/a candidato/a. I risultati di questa fase saranno pubblicati a partire dal giorno 20 marzo 2025.

- ✓ **FASE 2) Valutazione dei documenti di candidatura**. Sarà istituito un *Evaluation Committee* costituito da sei *Panel*, uno per ciascuna area tematica. Ciascun *Panel* sarà costituito da almeno 14 membri (*panelist*) (Art. 5 Commissione di valutazione).

  In un primo momento, i *panelist* valuteranno autonomamente e a distanza le candidature, assegnando il loro punteggio a ciascun/a candidato/a, secondo i criteri di valutazione previsti (4.4 Criteri di valutazione). Il *Panel* si riunirà poi fisicamente o telematicamente per discutere le singole valutazioni e raggiungere una valutazione consensuale.

  Per ciascuna area tematica, sulla base del punteggio assegnato, verrà definita una short list delle candidate e dei candidati ammessi alla Fase 3, che sarà pubblicata in forma anonima sul sito FutureData4EU a partire dal 31 marzo 2025. Attraverso il citato indirizzo di posta istituzionale, le candidate e i candidati ammesse/i alla Fase 3 saranno invitate/i ai colloqui (interviste), mentre coloro che non hanno superato la prova saranno informate/i dell'esito della Fase 2 di valutazione. Le interviste verranno programmate a partire dal 1 aprile 2025.
- ✓ **FASE 3) Intervista**. Tutte le interviste saranno condotte dai singoli *Panel* in lingua inglese e a distanza attraverso la piattaforma Microsoft Teams. Ogni colloquio durerà indicativamente 30 minuti. All'inizio del colloquio, ciascun/a candidato/a è tenuto/a a mostrare il documento di riconoscimento originale allegato alla domanda di ammissione. A ogni candidata/o verrà assegnato un punteggio secondo i criteri di valutazione previsti (4.4 Criteri di valutazione) e verrà assegnata una idoneità, a insindacabile giudizio della commissione, rispetto a una o più posizioni a bando. I risultati della Fase 3 saranno pubblicati in forma anonima sul sito FutureData4EU (https://site.unibo.it/futuredata4eu/en) a partire dal 30 aprile 2025 e della pubblicazione sarà data informazione alle candidate e ai candidati coinvolte/i attraverso il citato indirizzo di posta istituzionale.
- ✓ **FASE 4) Decisione finale e graduatoria**. L'*Evaluation Committee*, in collaborazione con il NAT, determinerà una graduatoria finale per ogni area tematica, sulla base dei punteggi ottenuti nelle fasi 2 e 3, indicando le idoneità acquisite in esito alla Fase 3 e proponendo l'assegnazione dei vincitori alle singole posizioni. Le 6 graduatorie finali saranno sottoposte all'approvazione dello *Steering Committee* di FutureData4EU. Le graduatorie finali saranno pubblicate sul sito FutureData4EU (https://site.unibo.it/futuredata4eu/en) in forma anonima a partire dal 15 maggio 2025 e della pubblicazione sarà data informazione alle candidate e ai candidati coinvolte/i attraverso il citato indirizzo di posta istituzionale. Le candidate e i candidati a cui è stata assegnata una delle posizioni

verranno informati tramite l'indirizzo di posta istituzionale sui successivi adempimenti relativi a contrattualizzazione e immatricolazione, a cura delle singole Università della regione. In caso di rinuncia, la posizione sarà assegnata nell'ordine della graduatoria al/la primo/a candidato/a idoneo/a per la medesima posizione (Art. 6 Graduatorie).

### 4.2. Procedura di ricorso

In esito alla comunicazione delle graduatorie finali, le/i candidate/i possono presentare domanda di ricorso giurisdizionale (entro 60 giorni) o ricorso straordinario (entro 120 giorni), come da normativa vigente, qualora ritengano che vi siano state carenze nelle procedure di valutazione che abbiano inciso sulla decisione finale della selezione. I ricorsi potranno riguardare solamente aspetti procedurali e/o errori materiali e non potranno invece riferirsi al giudizio degli esperti valutatori sulla qualità delle candidature.

### 4.3. Candidate e candidati con disabilità o disturbi specifici dell'apprendimento (DSA)

Le candidate e i candidati che vogliano avvalersi di adattamenti per la prova di ammissione devono farne richiesta, entro il termine di scadenza della domanda di ammissione.

Si precisa che trattandosi di una valutazione di requisiti di partecipazione e non essendo previste prove scritte, ma solamente un colloquio orale, la domanda di adattamenti dovrà essere presentata esclusivamente nei casi in cui si renda necessario per lo svolgimento dell'intervista (Fase 3).

Gli adattamenti possono consistere in:

- Possibilità di avere del tempo per pensare e organizzare le risposte;
- Domande in forma scritta durante il colloquio per candidati con disabilità uditiva;
- Altri adattamenti coerenti con le specifiche difficoltà certificate o con bisogni connessi alla situazione di salute (specificare gli adattamenti necessari).

L'elenco dei possibili adattamenti è disponibile sul modulo di richiesta adattamenti, come sotto specificato. Qualora, per esigenze organizzative e/o disposizioni cogenti, non sia possibile garantire l'adattamento richiesto sarà definita una misura alternativa di uguale valore compensativo.

La procedura per fare richiesta di adattamenti è la seguente:

- accedere a Studenti Online e accedere alla domanda di ammissione alla selezione;
- scaricare il *Modulo di richiesta adattamenti* (disponibile in formato pdf);
- caricare, nella sezione dedicata, il *Modulo di richiesta adattamenti* compilato (in formato pdf);

- caricare, nella sezione dedicata, anche la documentazione specialistica necessaria, come da specifiche richieste del *Modulo di richiesta adattamenti* compilato (in formato pdf).

Si raccomanda di non caricare in questa sezione dedicata alla richiesta di adattamenti altra documentazione non inerente.

Le candidate o i candidati con disabilità o con DSA residenti in Paesi esteri, che intendano usufruire di adattamenti, devono presentare la certificazione legalizzata (o con Apostille ove previsto) attestante lo stato di disabilità o di DSA rilasciata nel Paese di residenza, accompagnata da una traduzione ufficiale esclusivamente in lingua italiana o in lingua inglese.

La documentazione specialistica sarà esaminata dalle strutture competenti per accertare che la documentazione attesti una condizione di disabilità o di disturbo specifico dell'apprendimento riconosciuto dalla normativa italiana o nel Paese di residenza della/del candidato.

La documentazione viene esaminata dal Servizio per gli Studenti con Disabilità e con DSA per la valutazione della coerenza delle richieste degli adattamenti con la documentazione presentata. In caso di documentazione incompleta o poco leggibile sarà richiesta, mediante e-mail all'indirizzo di posta istituzionale nome.cognome@studio.unibo.it, un'integrazione che dovrà essere inviata nei termini perentori fissati nella comunicazione.

Alla candidata o al candidato che non presenti la richiesta come indicato sopra o non provveda a inviare eventuali documenti integrativi richiesti entro i termini indicati dal Servizio per gli Studenti con Disabilità e con DSA, non sarà possibile accordare gli adattamenti richiesti.

Gli adattamenti concessi sono comunicati sempre mediante e-mail inviata dall'indirizzo cofund@unibo.it all'indirizzo di posta istituzionale nome.cognome@studio.unibo.it.

Per chiarimenti solo in merito alla procedura di richiesta adattamenti è possibile rivolgersi al Servizio per gli Studenti con Disabilità e con DSA all'indirizzo mail ases.adattamentiammissione@unibo.it.

### 4.4. Criteri di valutazione

Le proposte saranno valutate secondo i criteri definiti di seguito.

**FASE 1: Controllo di Ammissibilità, a cura del NAT**

*Soglia per l'ammissione alla valutazione:* entrambi i criteri dovranno essere soddisfatti. Ad ogni

| | | |
|---|---|---|
| criterio sarà applicata una valutazione positiva/negativa (pass/fail). | | |
| Ammissibilità dei/delle candidati/e | Rispetto dei requisiti di ammissione (Art. 2 Requisiti di ammissione) | PASS/FAIL |
| Ammissibilità delle candidature | Rispetto della procedura di presentazione della domanda (Art. 3 Domanda di ammissione). | PASS/FAIL |
| **FASE 2: Valutazione dei documenti di candidatura, a cura dell'*Evaluation Committee*** *La fase 2 prevede l'assegnazione di un punteggio compreso tra 0-100.* *Soglia per l'ammissione allo Step 3*: 70/100. Interruzioni di carriera giustificate (ad es. maternità/paternità, servizio militare) non saranno oggetto di penalizzazione. | | |
| Valutazione del CV (punteggio 0-40) | *Si raccomanda l'utilizzo del modello CV di FutureData4EU.* Saranno valutati: formazione universitaria, competenza della lingua inglese, esperienze e risultati ottenuti (ad esempio esperienze di ricerca, premi/riconoscimenti, esperienze di mobilità internazionale), contributo alla proprietà intellettuale (ad esempio brevetti registrati), esperienze professionali, attinenza rispetto all'area tematica scelta. | max. 40 punti |
| Valutazione del progetto di ricerca (punteggio 0-50) | *Obbligatorio l'utilizzo del modello di FutureData4EU.* Saranno valutati: pertinenza e rilevanza | max. 50 punti |

| | | |
|---|---|---|
| | del progetto di ricerca proposto rispetto all'area tematica scelta e alle posizioni di dottorato a bando, chiarezza nella descrizione degli obiettivi, validità della metodologia proposta, coerenza delle competenze espresse rispetto al progetto di ricerca proposto. | |
| Valutazione delle Lettere di Referenza (punteggio 0-10) | Saranno valutate attinenza e rilevanza delle lettere di referenza presentate. | max. 10 punti |
| **FASE 3: Intervista a cura dell'*Evaluation Committee*** <br> *La fase 3 prevede l'assegnazione di un punteggio compreso tra 0-100.* <br> *Soglia per l'ammissione allo Step 4*: 70 / 100 <br> Tutte le interviste saranno effettuate tramite la piattaforma informatica Microsoft Teams in lingua inglese. | | |
| Eccellenza della candidata/del candidato e idoneità rispetto alle posizioni a bando (punteggio 0-100) | Sarà valutata la solidità della preparazione di base culturale e scientifica della/del candidata/o, la capacità di argomentare il proprio progetto di ricerca, la motivazione, le prospettive individuali di carriera. | max. 100 punti |
| **FASE 4: Graduatoria finale a cura dell'*Evaluation Committee*** <br> La graduatoria finale sarà formata sommando il punteggio attribuito nelle fasi 2 e 3 e conterrà la lista delle/i candidate/i che abbiano ottenuto un punteggio di almeno 140/200 punti. Conterrà inoltre per ciascun/a candidato/a l'indicazione della/e idoneità conseguita/e rispetto alle posizioni a bando. | | |

## Art. 5. Commissione di valutazione

### 5.1. Evaluation committee e Panel di valutazione

Sarà istituita una Evaluation Committee costituita da sei *Panel*. Ciascun *Panel* sarà costituito da almeno 14 rappresentanti scelti per garantire:

- Il corretto rapporto tra rappresentanti interni ed esterni a FutureData4EU: da 5 a 7 esperti proverranno dalle Università della regione coinvolte nel programma;
- La dimensione europea: da 4 a 5 esperti avranno come sede delle proprie attività un paese diverso dall'Italia;
- Presenza intersettoriale: da 3 a 4 esperti saranno selezionati tra i partner associati non accademici di FutureData4EU.

Ciascuna candidatura sarà valutata da almeno 7 membri: 3 rappresentanti delle università ospitanti, 2 esperti internazionali e 2 rappresentanti dei partner associati non-academici. Si cercherà di garantire un bilanciamento di genere, compatibilmente con la disponibilità dei rappresentanti coinvolti.

### 5.2. Nomina degli esperti: riservatezza e assenza di conflitto di interessi

A tutti gli esperti valutatori coinvolti nel processo di valutazione verrà richiesto di sottoscrivere un accordo di riservatezza in merito a informazioni e documenti acquisiti. Gli esperti dovranno altresì garantire l'assenza di qualsiasi conflitto di interessi.

## Art. 6. Graduatorie

Per ciascuna area tematica, la graduatoria finale sarà formata dall'*Evaluation Committee* (5.1 Evaluation committee e Panel di valutazione) sommando i punteggi ottenuti nelle Fasi 2 e 3.

In caso due o più candidate/i conseguano il medesimo punteggio, l'ordine in graduatoria sarà determinato, nell'ordine:

- dall'essere beneficiari/e di protezione internazionale (con status di rifugiate/i o beneficiarie/i di protezione sussidiaria);
- dal genere meno rappresentato tra gli assegnatari delle posizioni dell'area tematica senza considerare eventuali rinunce.
- dalla minore età anagrafica del/la candidato/a.

A suo insindacabile giudizio, l'*Evaluation Committee* esprimerà per ciascun/a candidato/a un giudizio di idoneità rispetto alle posizioni di dottorato a bando. Ciascun/a candidato/a potrà risultare idoneo per una o più posizioni.

Ciascuna posizione a bando sarà assegnata a insindacabile giudizio dell'Evaluation Committee ai candidati idonei per quella posizione sulla base della graduatoria di merito, nell'ordine del punteggio acquisito, e di idoneità rispetto a ciascuna posizione bandita.

Ciascun/a vincitore/vincitrice di una delle posizioni a bando sarà ammesso/a al corso di dottorato corrispondente, nell'Università che ha proposto la posizione, e invitato a sottoscrivere il contratto di assegno di ricerca con decorrenza il 1° novembre 2025.

Lo scorrimento della graduatoria potrà verificarsi a seguito di:

- rinuncia espressa alla posizione tramite comunicazione e-mail inviata dall'indirizzo di posta istituzionale (nome.cognome@studio.unibo.it) generata al momento della presentazione della domanda di ammissione all'indirizzo cofund@unibo.it;
- rinuncia tacita alla posizione tramite mancata conferma dell'accettazione della posizione entro i termini indicati, mancata sottoscrizione del contratto o mancata immatricolazione al corso di dottorato;
- mancata presentazione entro i termini della documentazione necessaria per la contrattualizzazione e l'immatricolazione.

In tali casi, la posizione vacante sarà proposta al/la successivo/a candidato/a idoneo/a secondo l'ordine della graduatoria stilata per quella specifica area tematica.

Si ricorda la scadenza del 15 settembre quale termine ultimo pena decadenza per la presentazione della documentazione richiamata all'art. 3.2 Documenti da allegare alla domanda di ammissione. Tale scadenza potrà essere prorogata solo ed esclusivamente in casi eccezionali, debitamente motivati, in seguito alla valutazione e approvazione dello Steering Committee ristretto.

Non sarà possibile scorrere la graduatoria oltre il termine del 31 luglio 2025.

## Art. 7. Contrattualizzazione e immatricolazione

Il/la vincitore/vincitrice sarà contrattualizzato con contratto di assegno di ricerca e sarà immatricolato al corso di dottorato dell'università di riferimento, secondo le specifiche indicazioni e scadenze che verranno comunicate.

## Art. 8. Contratto e trattamento economico

### 8.1. Contratto e condizioni di lavoro

Le singole Università coinvolte in FutureData4EU, che rivestono il ruolo di *Implementing Partners*, predisporranno un *employment contract* con le/i candidate/i, di durata triennale (36 mesi). La forma contrattuale proposta sarà l'Assegno di Ricerca (ex art. 22 Legge 30 dicembre 2010 n. 240), sottoscritta dalla/dal vincitrice/vincitore e dalla Direttrice/Direttore del Dipartimento ospitante e specificherà le condizioni di lavoro del dottorando/della dottoranda, gli obblighi previsti da FutureData4EU e dai regolamenti in vigore nelle singole università ospitanti. La sottoscrizione del contratto, alla quale la/il candidata/o si impegna entro il 31 ottobre 2025, comporta un impegno esclusivo e a tempo pieno.

L'Assegno di Ricerca è esente da imposte fiscali e prevede invece gli oneri previdenziali obbligatori (contributo a fini pensionistici, assicurazione contro gli infortuni sul lavoro, malattia, congedo di maternità, congedo di adozione e affidamento).

Durante i periodi di assenza dovuti ai congedi sopramenzionati o a infortunio, l'attività oggetto dell'assegno di ricerca sarà sospesa, previa opportuna comunicazione da parte del titolare del contratto di assegno. La durata del rapporto di lavoro si protrae per il residuo periodo, riprendendo a decorrere dalla data di cessazione della causa di sospensione.

Nel periodo di astensione obbligatoria per maternità l'indennità corrisposta dall'INPS è integrata fino a concorrenza dell'intero importo dell'assegno rapportato alle relative mensilità.

Il contratto può inoltre essere sospeso in caso congedo parentale, malattia o altre assenze prolungate che rendano oggettivamente impossibile lo svolgimento delle attività. In tali casi di sospensione, il contratto sarà prorogato per una durata corrispondente alla durata della sospensione.

### 8.2. Trattamento economico

L'importo annuale che viene corrisposto è pari a euro 27.238,83 (lordo percipiente) per i ricercatori/le ricercatrici senza responsabilità familiari. Tale importo annuale si compone di living allowance e di mobility allowance, quest'ultima a copertura delle spese di mobilità (es. trasferimento, spese di viaggio).

Le ricercatrici e i ricercatori che hanno obblighi familiari al momento dell'assunzione, o che contraggono tali obblighi in qualsiasi momento durante lo svolgimento del progetto, avranno diritto alla family allowance. Quest'ultima è riservata a coloro che sono uniti a un'altra persona con (i) matrimonio o (ii) relazione con status equivalente a un matrimonio riconosciuto dalla legislazione del paese in cui tale rapporto è stato formalizzato, o (iii) figli a carico che sono effettivamente mantenuti dal candidato/dalla candidata.

Il progetto di ricerca svolto dalle candidate e dai candidati avrà a disposizione un sostegno finanziario per i costi di ricerca, formazione e networking, utilizzabile per l'acquisto di materiali e strumentazioni di ricerca, per i costi relativi alle pubblicazioni, le spese di viaggio (ad es. per la partecipazione a conferenze/corsi di formazione, attività di networking) e servizi esterni. Il finanziamento sarà gestito dal Dipartimento ospitante e sarà soggetto all'approvazione del rispettivo Supervisore.

## Art. 9. Inizio corsi e tasse universitarie

Le candidate e i candidati selezionati saranno iscritti ai Corsi di Dottorato di FutureData4EU avviati nell'Anno Accademico 2025/2026. Il percorso dottorale FutureData4EU avrà inizio il 1° novembre 2025.

Le dottorande e i dottorandi FutureData4EU sono esonerati dal pagamento di eventuali contributi per la frequenza dei corsi di dottorato di ricerca. Sono tenuti a pagare gli oneri di iscrizione ai corsi, costituiti dalla tassa regionale per il diritto allo studio, dall'imposta di bollo e dal premio di assicurazione. Tali oneri verranno poi rimborsati.

## Art. 10. Obblighi delle dottorande e dei dottorandi di FutureData4EU

### 10.1. Attività delle/dei dottorande/i FutureData4EU

Le dottorande e i dottorandi di FutureData4EU sono tenute/i a svolgere le attività relative al progetto di ricerca che verrà loro assegnato, che non sarà necessariamente il progetto proposto dal/la candidato/a in fase di presentazione della domanda di ammissione. Il progetto di ricerca da svolgere durante il corso di dottorato sarà approvato dal Collegio dei docenti del Corso di Dottorato di afferenza cui risulteranno regolarmente

iscritti. Il progetto di ricerca sarà parte del piano di sviluppo di carriera del ricercatore, che insieme alle attività formative previste, sarà formulato congiuntamente con il proprio Supervisore. Ogni anno, a seguito della valutazione dell'attività svolta dalla/dal dottoranda/o FutureData4EU, il competente Collegio dei docenti del Corso di Dottorato di afferenza delibererà l'ammissione del/la dottorando/a FutureData4EU all'anno successivo. Con motivata deliberazione, l'organo competente può proporre l'esclusione dal proseguimento del Corso.

### 10.2. Periodi di secondment

Per garantire che le dottorande e i dottorandi di FutureData4EU ricevano la formazione più innovativa e all'avanguardia e beneficino pienamente di tutte le opportunità offerte, sono raccomandati 2 periodi di secondment: uno presso un ente accademico in Europa della durata di 6-8 mesi, il secondo svolto presso un ente non accademico (intersettoriale) della durata di 4-6 mesi. La durata complessiva dei periodi di secondment non dovrà superare 12 mesi.

### 10.3. Pubblicazioni

Tutte le pubblicazioni scientifiche risultanti dalla ricerca finanziata nell'ambito del presente bando devono essere *open access*. Inoltre, in tutte le pubblicazioni e nel materiale divulgativo (ad es. poster presentati nell'ambito di conferenze), le dottorande e i dottorandi di FutureData4EU sono tenuti a menzionare il programma di finanziamento includendo la bandiera dell'Unione Europea seguita dalla dicitura: "*Co-funded by the European Union*" e il disclaimer: "*Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them*".

## Art. 11. Conseguimento del titolo

L'assegnazione del titolo di dottore di ricerca è subordinata al pieno rispetto dei regolamenti del dottorato di ricerca in vigore nelle singole università ospitanti.

È previsto un esame finale che consiste nella discussione, da parte del/la candidato/a, della sua tesi.

## Art. 12. Proprietà dei risultati e confidenzialità

I diritti di proprietà intellettuale e industriale sui risultati eventualmente conseguiti dal dottorando, inclusi, a titolo esemplificativo e non esaustivo, software, invenzioni industriali brevettabili o meno, know-how, modelli,

dati e raccolte di dati, sono regolati in conformità alla normativa vigente e ai regolamenti del singolo Ateneo di riferimento ed eventualmente, in base a quanto stabilito nelle singole convenzioni o accordi con Università, imprese o enti coinvolti.

Le dottorande e i dottorandi di FutureData4EU hanno l'obbligo di comunicare senza ritardo al proprio Supervisore il conseguimento dei risultati, impegnandosi a non divulgarli e a non utilizzarli senza la preventiva autorizzazione dell'Ateneo di riferimento.

Le dottorande e i dottorandi di FutureData4EU sono, inoltre, tenuti/e a sottoscrivere apposito impegno di riservatezza e riconoscimento dei diritti di proprietà intellettuale in relazione alle informazioni, dati e documenti di natura riservata di cui dovesse venire a conoscenza nello svolgimento della propria attività presso e/o per conto dell'Ateneo di riferimento.

Alle dottorande e ai dottorandi è, in ogni caso, garantita la possibilità di effettuare le ordinarie attività di pubblicazione previste dal percorso formativo, che dovranno essere programmate in maniera compatibile con la protezione degli eventuali risultati.

## Art. 13. Principi etici

Le attività di ricerca e di innovazione previste devono essere rispettose delle norme e dei principi etici nazionali, internazionali e dell'Unione Europea. Particolare attenzione deve essere posta al principio di proporzionalità, al diritto alla privacy, al diritto alla protezione dei dati personali, al diritto all'integrità fisica e mentale di una persona, al diritto alla non discriminazione e alla necessità di garantire livelli elevati di protezione della salute umana. Le attività di ricerca e di innovazione proposte devono avere un focus esclusivo sulle applicazioni civili.

## Art. 14. Trattamento dei dati personali

Ai sensi dell'art. 13 del Regolamento (UE) 2016/679, il trattamento dei dati personali forniti dai candidati in sede di partecipazione al bando o comunque acquisiti a tal fine dalle Università è finalizzato all'espletamento delle attività di selezione e alla gestione delle relative operazioni e attività connesse. I dati saranno trattati dalle persone preposte al procedimento di selezione, ivi comprese l'Evaluation Committee, nei modi, nei limiti e nei tempi necessari per perseguire le predette finalità, che possono anche eventualmente prevedere la comunicazione a terzi, per le finalità definite nel presente bando. La base giuridica del trattamento è da rinvenirsi negli artt. 6, paragrafo 1, lettere c) (trattamenti per obblighi di legge) ed e) (trattamenti per ragioni

di interesse pubblico) e 9, paragrafo 2, lettera g) (trattamenti per motivi di interesse pubblico) del Regolamento (UE) 2016/679.

Ai fini della presente procedura di valutazione e selezione dei candidati ai corsi di dottorato, i contitolari del trattamento dei dati sono:

- Alma Mater Studiorum - Università di Bologna: sede legale via Zamboni n. 33, 40126 – Bologna, Italia; Responsabile della protezione dei dati personali e-mail: dpo@unibo.it;mailto: PEC: scriviunibo@pec.unibo.it;
- Università di Ferrara: sede legale via Ludovico Ariosto n. 35, 44121 Ferrara, Italia; Responsabile della protezione dei dati personali e-mail privacy@unife.it, dpo-team@lepida.it; PEC: ateneo@pec.unife.it;
- Università degli studi di Modena e Reggio Emilia: sede legale via Università n. 4, 41121 Modena, Italia; Responsabile della protezione dei dati personali e-mail: dpo@unimore.it; PEC: dpo@pec.unimore.it;
- Università di Parma: sede legale via Università n. 12, 43121 Parma, Italia; Responsabile della protezione dei dati personali e-mail: dpo@unipr.it; PEC: dpo@pec.unipr.it;

Ciascuna Università, quale autonomo titolare del trattamento per le fasi successive alla selezione, conserverà e utilizzerà i dati personali e i contatti forniti dagli iscritti ai corsi di dottorato anche in seguito all'espletamento delle procedure di selezione, per adempimenti operativi, amministrativo-contabili e/o di altra natura connessi alla gestione delle attività istituzionali e progettuali e per adempimenti legati ad obblighi di legge, nonché per la divulgazione di eventuali opportunità (borse di studio, premi, ecc.).

I dati personali per la successiva procedura di contrattualizzazione e immatricolazione saranno raccolti e trattati da parte di ciascun Ateneo di riferimento, in qualità di autonomi titolari del trattamento, nel rispetto della stessa normativa sopracitata e in conformità alle rispettive informative sul trattamento dei dati personali reperibili sui siti web istituzionali di ciascun Ateneo sopra indicati. Potranno essere condivisi con Alma Mater Studiorum – Università di Bologna per le esigenze progettuali di rendicontazione e audit.

Il conferimento dei dati è comunque indispensabile per consentire l'iscrizione alla procedura di selezione e la successiva contrattualizzazione e l'immatricolazione; l'eventuale rifiuto a fornirli comporta l'impossibilità di procedere con la selezione e l'eventuale successiva ammissione ai corsi di dottorato.

Alle/ai candidate/i è riconosciuto il diritto di accedere ai propri dati personali, conferiti sia in fase di partecipazione al concorso, sia in fase di contrattualizzazione e immatricolazione, di chiederne la rettifica, la

cancellazione, la limitazione del trattamento, nonché di opporsi al loro trattamento rivolgendo le richieste agli uffici di competenza del singolo Ateneo di riferimento.

Gli interessati che ritengono che il trattamento dei propri dati personali avvenga in violazione di quanto previsto dal Regolamento Europeo sopra citato possono sporgere reclamo al Garante o adire le opportune sedi giudiziarie.

## Art. 15. Norme finali

Per quanto non previsto dal presente bando si rinvia ai Regolamenti in materia di corsi di dottorato delle Università di riferimento, ai DD.MM. 226/2021 e 301/2022, alla articolo 22 della L. 240/2010 e ss.mm.ii e alle relative disposizioni delle Università di riferimento.

La presentazione della domanda di partecipazione alle selezioni implica l'accettazione da parte della candidata o del candidato delle disposizioni contenute nel presente bando e nei regolamenti in materia di corsi di dottorato, regolamenti in materia di assegni di ricerca e della normativa relativa al progetto FutureData4EU.

Si riserva la facoltà di accertare la veridicità delle dichiarazioni sostitutive di certificazioni o di atti di notorietà rese dai candidati/dalle candidate e ai sensi del D.P.R. 445/2000, in ogni fase della procedura. Qualora dal controllo sopra indicato emerga la non veridicità del contenuto delle dichiarazioni, la/il dichiarante decade dai benefici eventualmente conseguenti dal provvedimento emanato sulla base della dichiarazione non veritiera, fermo restando le disposizioni di cui all'art. 76 del decreto del D.P.R. 445/2000, in merito alle sanzioni previste dal codice penale e dalle leggi speciali in materia.

Il responsabile del procedimento è la Dott.ssa Verdiana Bandini – Dirigente Area Ricerca (ARIC) dell'Alma Mater Studiorum - Università di Bologna.

Per chiarimenti o informazioni relativi a questo bando è possibile rivolgersi a: cofund@unibo.it.

Il presente bando è tradotto anche in lingua inglese a soli fini informativi; per ogni effetto di legge è valida esclusivamente la versione italiana.

## Allegato 1 - Schede di Dottorato e temi di ricerca FutureData4EU

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA | AREA RICERCA

FutureData4EU
Training Future Big Data Experts for Europe

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ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA | AREA RICERCA

FutureData4EU
Training Future Big Data Experts for Europe

**Thematic Area 1 – Health**

UNIVERSITÀ DI BOLOGNA (UNIBO)

# Enhancing Dermatologic Interventions through Big Data-Driven Understanding of Placebo Effects

## Doctoral Position

**Enhancing Dermatologic Interventions through Big Data-Driven Understanding of Placebo Effects**

## Doctoral Programme

Surgical Sciences and Innovative Technologies

## Description of the doctoral position's main topic

The doctoral research within the COFUND research project 'Futuredata4EU' will focus on advancing our understanding of placebo and nocebo effects in dermatology, as outlined in the project's overarching aim. This research topic holds significant relevance due to its potential to revolutionise dermatologic treatment strategies and enhance patient outcomes.

At the regional level, the project aims to collaborate with dermatology clinics and research centres to collect diverse datasets encompassing patient demographics, clinical profiles, and treatment outcomes. The project's findings will contribute to addressing critical gaps in psycho-neuro-biological research within dermatology, aligning with national priorities for advancing healthcare innovation and personalized medicine. By leveraging big data analytics and machine learning techniques, the research will pave the way for novel therapeutic approaches tailored to individual patient characteristics and expectations, thus enhancing the effectiveness and sustainability of dermatologic treatments nationwide. The project will engage with national and international leading experts in placebo and nocebo, dermatology, neuroscience, and data science. This international collaboration will facilitate the data collections and the dissemination of research findings, establishment of best practices, and potential harmonization of clinical trial designs across borders, ultimately benefiting patients worldwide. Moreover, participation in this doctoral research offers candidates a unique opportunity to delve into cutting edge interdisciplinary research at the intersection of psychology, dermatology, neurobiology, and data science. The project's emphasis on creativity,

independence, and innovation aligns with the career aspirations of aspiring researchers, providing a solid foundation for future career advancement in academia, industry, or clinical practice.

Candidates embarking on this doctoral research journey will have the chance to develop their own project ideas within the broader research topic of placebo and nocebo effects in dermatology. This opportunity fosters creativity and critical thinking, empowering candidates to shape their research trajectory and contribute novel insights to the field. Furthermore, the interdisciplinary nature of the research opens doors to diverse career pathways, including academia, healthcare management, pharmaceutical research, and data science, thereby enhancing the candidates' employability and professional growth prospects.

In summary, the doctoral research within the COFUND project 'Futuredata4EU' offers a dynamic and intellectually stimulating environment for candidates to explore the intricate relationship between patient expectations, treatment outcomes, and neurobiological mechanisms in dermatology. With its regional, national, and international implications, this research topic promises to catalyse innovation in dermatologic care and provide candidates with valuable skills and opportunities for future career development.

## Sub-themes of the doctoral position's main topic (if any)

None

## Potential Supervisors

Katia Mattarozzi, Bianca Maria Piraccini, Gastone Castellani, Emanuela Marcelli, Arianna Bagnis, Andrea Evers.

## Doctoral candidate's desirable skills and competences

***Scientific and technical skills***

Expertise in placebo and nocebo effects, with a strong understanding of neurobiological mechanisms underlying these phenomena.

Proficiency in dermatology, including knowledge of dermatologic conditions, treatment modalities, and patient care.

Demonstrated research experience in related fields, preferably with a focus on psychosocial aspects of healthcare and clinical trials.

***Other skills***

Familiarity with big data analytics and data mining techniques, enabling the candidate to analyse diverse datasets effectively.

Experience in interdisciplinary research, particularly in collaborative projects involving multiple scientific disciplines.

Proficiency in statistical analysis software such as R or Python, facilitating data interpretation and modelling.

## Description of the research group(s) in which the doctoral candidate will be integrated

Katia Mattarozzi, Associate Professor of Psychology at the University of Bologna, leads research focused on top-down modulation of pain and Patient-Reported Outcome Measures (PROMs). She also spearheads the PANACEA ERASMUS+ Programme, which explores "Special Needs by Placebo" to Advise, Normalize, and Control its European Administration.

Bianca Maria Piraccini, Full Professor in Dermatology at the University of Bologna, specializes in disorders of skin appendages, hair, and nails, providing invaluable clinical insights into dermatologic conditions. Gastone Castellani, Full Professor of Applied Physics at the University of Bologna, brings expertise in big data and algorithmic decision-making, leading EU projects such as HARMONY, Genomed4All, and SYNTHEMA, all dedicated to Big Data Analytics and Machine Learning.

Emanuela Marcelli, Associate Professor of Biomedical Engineering at the University of Bologna, offers expertise in utilizing innovative technologies and sensors to monitor health conditions and assess therapeutic treatment effects in patients.

Arianna Bagnis, Postdoctoral Researcher at the University of Bologna, focuses on top-down modulation of pain and serves as project manager of the PANACEA program, further enhancing the group's understanding of placebo mechanisms.

Furthermore, the collaboration with Andrea Evers, Full Professor of Health Psychology at the University of Leiden, strengthens the group's expertise in placebo studies, particularly in dermatology, through their long-term partnership in the PANACEA ERASMUS+ project. The group's affiliation with the European Academy of Dermatology & Venereology (EADV) provides access to a broader network of dermatologists and researchers, fostering knowledge exchange and collaboration.

## Existing facilities that will be accessible and available to the doctoral candidate to conduct her/his research

Candidate will have access to robust computing resources necessary for processing and analysing large-scale datasets such as in-house cluster of 20 servers, equipped with 64-core Xeon processors, >20TB Hard Disk and 256 GB RAM each, for bioinformatics analyses purposes, equipped with all available software suites (Python, R, Julia, Matlab, C++). Leveraging big data methodologies, including data mining and machine learning algorithms, our computational infrastructure will enable the integration and analysis of diverse datasets such as Randomized Controlled Trials (RCTs) data, electronic health records, and patient-reported outcomes. This computational framework will serve as the cornerstone for identifying patterns and predictors associated with placebo and nocebo responses, ultimately leading to the development of predictive models for treatment outcomes.

## Collaboration networks involving the research team

- European Academy of Dermatology & Venereology (EADV)
- A non-academic institution providing access to a broader network of dermatologists and researchers. EADV serves as a platform for knowledge ex-change and collaboration, further enriching the program's scientific ecosystem.
- Panacea Cooperation Partnership https://site.unibo.it/educationonplacebo/en
- SIPS https://placebosociety.org/home
- EFIC https://europeanpainfederation.eu/
- University of Cambridge UK
- Politecnica University of Madrid ESP

## International and/or national and/or regional projects in which the research team is currently involved or has accessed through competitive calls, activated within the last 5 years, or set to start within 1 year

Project HARMONY; Funding: Innovative Medicines Initiative (IMI) and European Union's Horizon 2020 Research and Innovation Programme and the European Federation of Pharmaceutical Industries and Associations (EFPIA); Unit Project Leader: Gastone Castellani, University of Bologna;

Project: Genomed4All; Funding: European Union's Horizon 2020 research and innovation programme under grant agreement No 101017549; Unit Project Leader: Gastone Castellani, University of Bologna;

Project: SYNTHEMA; Funding: European Union Horizon Europe; PI: Gastone Castellani, University of Bologna; all devoted to Big Data Analytics and Machine Learning, University of Bologna.

Project: PANACEA "Special Needs by Placebo: Programme to Advise, Normalize and Control its European Administration (PANACEA)"; Funding: European Commission, Action Erasmus+ Ka220-HED Cooperation Partnerships; PI: Katia Mattarozzi, University of Bologna.

UNIVERSITÀ DI FERRARA (UNIFE)

# Evolutionary perspective on health and medicine through the lens of paleogenomics

## Doctoral Position

**Evolutionary perspective on health and medicine through the lens of paleogenomics**

## Doctoral Programme

Life Sciences and Biotechnology

## Description of the doctoral position's main topic

Disentangling the history of human biological adaptation has fascinated scientists for more than a century. How did humans evolve in response to the new environments they encountered while expanding from Africa? How ancient human populations responded genetically to cultural changes such as the dietary shifts associated with the onset of agriculture? Do our past adaptations have consequences for health and medicine today?

Since 2010, advancements and the subsequent broad applications of next-generation sequencing techniques have enabled rapid and cost-effective sequencing of eukaryotic genomes and paved the way for a genomic era in the field of ancient DNA, which is now established as a new discipline, called Paleogenomics. Ancient DNA provides a glimpse into the genetic history of humans across the globe over the past millennia. The study of paleogenomic data made it possible to examine the deep past of human populations, and to explore the genetic makeup and adaptation dynamics of archaic lineages and of ancient and present-day populations. The sequencing of Neanderthal and Denisovan genomes has revealed a complex history of admixture between archaic humans and the ancestors of modern humans. Consequently, archaic sequences became part of the modern human gene pool, possibly influencing life and health of our ancestors, as well as of living individuals. For example, lines of evidence suggest that genetic variants introgressed from archaic hominins may have affected genes associated with immunity, or pharmacogenes - genes involved in drug metabolism - as these genes can relate to changing environments, and beneficial variants may have been positively selected by modern humans. In addition, modern human population dynamics had a pivotal role in shaping the current pattern of genomic diversity. Within the past 10,000 years, we observed two main genetic turnovers in Europe, namely the Neolithic transition and the expansion of farming communities from Anatolia, and the migration from Pontic-Caspian Steppe during Bronze Age. These population dispersals,

changing lifestyle and higher population density, may have resulted in increased transmission of pathogens, driving selection of variants in immune response genes, and triggered important changes in the adaptive evolution of our species both at local and global scales. While the availability of thousands of ancient genomes gives us the opportunity to unveil the history of human adaptation at unprecedented depth and precision, the study of the contribution of archaic and ancient alleles to current human health is still in its infancy. Shedding light on adaptive evolutionary dynamics of our species would promote a more comprehensive reconstruction of our past, sharpening the current understanding of our present. The results of this project will pioneer the field of Evolutionary Medicine, thus providing significant contributions to biomedical research and medical applications.

## Sub-themes of the doctoral position's main topic (if any)

The availability of thousands of high-quality ancient genomes can help the identification of rare variants introgressed from archaic and ancient humans into the modern populations to address key questions related to human health and disease. Studies on modern humans shown that differential outcomes after infection are due to specific DNA mutations that alter host defense mechanisms. However, little is known about adaptation of archaic and ancient humans to past environments and pathogens. Therefore, studying genetic variants associated with infectious-disease risks in fossil remains, highlight the potential value of paleogenomics in medicine.

Recent studies pointed out the value of using ancient DNA to reconstruct the evolutionary history of immune disorders and past epidemics. Kerner et al. (2021) found a tuberculosis risk variant in ancient genomes that has evolved under strong negative selection over the past two millennia, probably reflective of the pressure imposed by Mycobacterium tuberculosis. Ancient DNA can also be used to identify advantageous mutations that are positively selected over time through pathogen exposure. For example, some immunity-related genes under positive selection have been found to be associated with the Neolithic transition in Europe. This is the case for IL1R2, for which high levels of expression are associated with protection against several autoimmune disorders.

Lastly, the study of genetic variants inherited from the admixture between modern and archaic humans can help us to disentangle adaptation processes to new environments and host resistance to pathogens. An example is the adaptation of Tibetan populations to high altitudes due to the introgression of adaptive alleles from Denisovans. Another case is provided by a Neanderthal haplotype at the antiviral OAS1 that was

recently shown to be associated with protection against severe COVID-19. These findings can open new avenues to find candidate drug targets in disease treatment.

Keywords:

- Legacy of archaic humans
- Immune disorders
- Adaptation to pathogens
- Co-evolution pathogens-host

## Potential Supervisors

Silvia Ghirotto, Andrea Benazzo, Silvia Fuselli

## Doctoral candidate's desirable skills and competences

***Scientific and technical skills***

The ideal candidate should have a graduate degree in biology, genetics, or a closely related field, and a strong interest in bioinformatics. The candidate should have a good computational background (basic knowledge of R, Python or Bash programming languages are mandatory); experience with cluster computing environments would be appreciated but it is not mandatory. He/she should also have a good population genetics background.

The work will focus intensively on bioinformatics and biostatistics to handle and analyze genomic data. The candidate will have a primary role in the processing and management of genomic data (ancient and modern), as well as the development of methods to infer demographic and evolutionary processes using genomic data.

***Other skills***

We are looking for a motivated PhD candidate, hardworking, and interested in addressing scientific problems with rigor and creativity. The candidate will need to communicate and write in English; fluent level of English is recommended.

## Description of the research group(s) in which the doctoral candidate will be integrated

The candidate will be supervised by Prof. Silvia Ghirotto (associate professor at UNIFE since 2018, total citations 1521, h-index 23, (Scopus, 19/03/2024), qualified to full professor in Genetics and in Anthropology in 2021), a geneticist specialized in population genetics. She published 53 original papers, almost all about

population genetics analysis of human evolutionary history and development of methods for the analysis of genomic data. The complete list of Prof. Ghirotto's publications can be found here: https://scholar.google.com/citations?hl=it&user=ZiSeXpIAAAAJ. At the moment, Prof. Ghirotto is leading a national project involving five different academic units, aiming to reconstruct the demographic and evolutionary history of human presence in the three main Mediterranean islands (Sicily, Sardinia and Corsica); she is also responsible for the UNIFE unit in other two national projects, aiming to shed light on the past human dynamics in the Italian peninsula and to perform evolutionary inference of past processes from dental calculus metagenomic data. She is also directing a national project aiming to study the origin of social inequalities in Northern Italy from a paleogenomic perspective. Prof. Ghirotto coordinates a research group (Ghirotto Lab, website: https://ghirotto-lab-at-university-of-ferrara.github.io/) composed by two postdoctoral researchers, two PhD students, and a fellowship researcher. The research group has extensive experience in bioinformatic analysis and in statistical methods applied to the analysis of modern and ancient genomic data. The research work focuses on the reconstruction of evolutionary processes that shaped current and past patterns of genomic variation, exploring and interpreting human genetic variation together with evidence from other fields, such as anthropology, archaeology, and linguistics. Prof. Ghirotto group is also primarily involved in the development and the analysis of statistical methods, mainly based on computer simulations and machine learning approaches, to infer past population dynamics and to test among different evolutionary scenarios. Prof. Ghirotto research group is integrated within the Population Genomics laboratory of the University of Ferrara. The Population Genomics laboratory team is composed by Prof Guido Barbujani, whose research focuses on human evolutionary genetics, Prof Giorgio Bertorelle and Dr Andrea Benazzo, whose research focuses on evolutionary and conservation genomics, Dr Silvia Fuselli, whose research focuses on molecular evolution and pharmacogenomics, Prof Chiara Scapoli and Dr Elisabetta Mamolini, whose research focuses on human genetics.

## Existing facilities that will be accessible and available to the doctoral candidate to conduct her/his research

The host will give all the support in the completion of the project goals. Life Sciences and Biotechnology Department at UNIFE has a long-lasting tradition of advanced studies in populations genetics and genomics, micro and macro evolutionary processes and biostatistics. It has a large team of people working in transversal and multidisciplinary themes. It frequently hosts visiting researchers. The doctoral candidate will be integrated into Prof. Silvia Ghirotto group, in the Population Genomics laboratory, which has an impressive

reputation internationally for the quality and productivity of its members and for the breadth of its expertise. It is a highly attractive laboratory with researchers that cover a broad area of expertise's for the study of populations evolutionary history and development of methods for the analysis of genomic data. Upon beginning of the project, UNIFE will provide a desk space, access to a workstation, web, digital library, high-throughput computational resources, personalized assistance on administrative matters, etc. The host offers magnificent facilities and infrastructure to carry out this project at a European scale. It offers a High-Performance Computing (HPC) System composed by 14 computing nodes, 5 storage servers and 2 login nodes. The total amount of computing resources is 824 cores, 2.9 TB of RAM and 205 TB of storage capacity; access through proposal submission to large CINECA (Consortium of 70 Italian Universities) computing resources. The candidate will have the opportunity to participate in the weekly group seminars, guest talks and discussions sessions to capitalize on local networking chances, increase collaborations with geneticists and bio-staticians. He/she will be working in an inter-disciplinary environment and in a highly dynamic and enriching research institution. UNIFE have an International Research office providing all the assistance needed to staff and research fellows.

## Collaboration networks involving the research team

The PI of the research group, Prof. Silvia Ghirotto, has been primarily involved in national and international collaborations which aimed to reconstruct past population dynamics through a multidisciplinary approach, and has documented experience in leading research projects, as PI or local coordinator (PRIN 2017, FIR 2018, PRIN 2020, PRIN-PNRR 2022, PRIN 2022). The research group has several well-established national and international collaborations in different fields (anthropology, archaeology, molecular anthropology, bioinformatics and population genetics) from which the candidate will benefit to ensure the achievement of the project goals. The PI has an established collaboration (since 2015) with the multidisciplinary DFG Center for Advanced Studies "Words Bones Genes Tools" of the University of Tubingen, of which she is an External Scientific Member. Collaborations with national molecular anthropologists from the University of Florence (Prof. David Caramelli, Dr. Stefania Vai and Prof. Martina Lari); international archaeologists from the CNRS in the University of Bordeaux (Prof. Solange Rigaud); populations geneticists from the University of Cambridge (Prof. Andrea Manica) and Muséum National d'Histoire Naturelle in Paris (Prof. Stefano Mona).

## International and/or national and/or regional projects in which the research team is currently involved or has accessed through competitive calls, activated within the last 5 years, or set to start within 1 year

- PRIN2017 - 1000 Ancient Italian Genomes: Evidence from ancient biomolecules for unravelling past human population Dynamics (AGED) Ministero dell'Istruzione dell'Università e della Ricerca (MIUR) – Bando PRIN. PI: Prof. David Caramelli. Co-PI: Prof Silvia Ghirotto, Prof. Donata Luiselli, Prof. Olga Rickards, Prof. Sarti Lucia, Prof. Sineo Luca. Team members are responsible for collecting, processing, and analyzing whole genome data from both modern and ancient humans.
- PRIN2020 - Crossing the sea: ancient and modern human genomes to study the evolutionary dynamics of Sicily, Sardinia and Corsica. Ministero dell'Istruzione dell'Università e della Ricerca (MIUR) – Bando PRIN. PI: Prof. Silvia Ghirotto. Co-PI: Dr. Stefania Vai, Prof. Paolo Francalacci, Prof. Luca Sineo and Prof. Marco Sazzini. Team members are responsible for collecting, processing, and analyzing whole genome data from both modern and ancient humans.
- PRIN2022 – Investigating the transition from hunter-gathering to farming in Southern Italy through metagenomic and population genetic analysis of ancient human dental calculus. Ministero dell'Istruzione dell'Università e della Ricerca (MIUR) – Bando PRIN. PI: Prof. Martina Lari. Co-PI: Prof. Silvia Ghirotto. Team members are responsible for collecting, processing, and analyzing whole genome data from dental calculus ancient samples.
- PRIN-PNRR2022 – The origin of social inequalities in Northern Italy: clues from ancient genomes. Ministero dell'Istruzione dell'Università e della Ricerca (MIUR) – Bando PRIN-PNRR. PI: Prof. Silvia Ghirotto. Co-PI: Dr. Stefania Vai. Team members are responsible for collecting, processing, and analysing whole genome data from archaeological human remains.
- BANDO A CASCATA - Progetto "NATIONAL BIODIVERSITY FUTURE CENTER - NBFC" SPOKE 3 "ASSESSING AND MONITORING TERRESTRIAL AND FRESHWATER BIODIVERSITY AND ITS EVOLUTION: FROM TAXONOMY TO GENOMICS AND CITIZEN SCIENCE". Project title (in Italian): Biodiversità ittica nel basso corso del fiume Po: un modello di studio degli effetti dei cambiamenti globali nei grandi fiumi (BioPo).

UNIVERSITÀ DI MODENA E REGGIO EMILIA (UNIMORE)

Big-data from single-cell multiomics in somatic stem cells for clinical application

## Doctoral Position

**Big-data from single-cell multiomics in somatic stem cells for clinical application**

## Doctoral Programme

Molecular and Regenerative Medicine

## Description of the doctoral position's main topic

Since 1980s, cultures of human epithelial cells (keratinocytes) have been extensively used in clinical applications to regenerate a functional cornea and epidermis in patients affected by severe burns. first successful combined cell and gene therapy for patients suffering from a specific form of Epidermolysis Bullosa (EB), namely recessive LAMB3-dependent Junctional EB (JEB), was pioneered by this research group (Mavilio et al., 2006). This approach relied on the use of transgenic epidermal grafts, prepared from clonogenic keratinocytes cultures transduced with a γ-retroviral vector carrying full-length LAMB3 cDNA (Mavilio et al. 2006, De Rosa et al. 2014, Bauer et al, 2017; Hirsch et al., 2017). It has been demonstrated that combined ex vivo cell and gene therapy can be lifesaving (Hirsch et al., 2017). We were able to restore virtually the entire epidermis of a 7-year-old child with a devastating form of JEB, having very poor prognosis, using a live-saving transgenic epidermal cultures (Hirsch et al., 2017). 8 years after grafting the child's transgenic epidermis is stable and robust (Kuckelhaus et al., 2023). Clonal tracing, using proviral integrations as clonal genetic marks, performed on the regenerated transgenic epidermis, has formally proven that the human epidermis is sustained solely by self-renewing long-lived stem cells. These stem cells, identified as holoclone-forming cells, give rise to pools of short-lived transient amplifying (TA) progenitors, which in turn produce meroclones and paraclones.

JEB represents a small percentage (~5%) of all EBs (Fine, 2016), and several hindrances hamper ex vivo gene therapy for other forms of EB: i) over 50% of EB forms are dominantly inherited, hence cannot be tackled by viral-mediated gene addition. ii) current gene editing approaches would transduce epidermal stem cells with insufficient efficiency. iii) holoclone-forming cells cannot be prospectively isolated, since specific cell membrane markers allowing their isolation have not yet been identified.

Microarray and single cell RNA-seq data have been used to understand the basic mechanisms of stem cell function in culture (Enzo et al. 2021). We confirm that holoclone-forming cells display stem cell features, such as genes regulating DNA repair, chromosome segregation, spindle and microtubule organization and telomerase activity.

In this project, we aim to combine cutting-edge single-cell transcriptomic and epigenetic data with Artificial Intelligence to better characterize squamous epithelial stem cells at a molecular level. All this data will be used for the creation of an integrated atlas of in vitro cultured human epithelial cells from the different anatomical compartment. The multiomic data will be subjected to machine learning algorithms to develop a user-friendly tools for estimating the characterization of each type of cells, providing a comprehensive understanding of the molecular profile of stem cells, transient amplifying progenitors, and fully differentiated cells from each of these epithelia.

Our international network in regenerative medicine and gene therapy provides a fertile ground for PhD students. Many of these bright minds, having honed their skills and knowledge during their PhD with us, subsequently joined other esteemed groups led by renowned experts in the field. This exchange contributes to the advancement of the scientific community and perpetuates a legacy of excellence and innovation.

## Sub-themes of the doctoral position's main topic (if any)

None

## Potential Supervisors

Michele De Luca, Graziella Pellegrini, Laura De Rosa.

## Doctoral candidate's desirable skills and competences

***Scientific and technical skills***

The candidate should have a Master's degree in science, preferably in molecular biosciences (molecular, cellular, and developmental biology, genetics, or genomics). Practical experience in developmental biology, genetics, microscopy, genomics, or bioinformatics is an advantage.

***Other skills***

The candidate should be able to communicate well in both written and spoken English.

## Description of the research group(s) in which the doctoral candidate will be integrated

The research group is led by three principal investigators: Prof. Michele De Luca, Prof. Graziella Pellegrini, and Prof. Laura De Rosa. Additionally, there are three senior researchers (Dr. Elena Enzo, Eustachio Attico, and Eleonora Maurizi) who oversee the coordination of postdoctoral fellows and PhD students. Our research focuses on understanding the molecular mechanisms of self-renewal and differentiation of epithelial cells, as well as the application of cell and gene therapy for various diseases affecting the cornea, skin, and respiratory tract. We conduct primary keratinocyte cultures and perform single-cell transcriptomic and epigenomic experiments, including ATAC-seq and gene expression analysis. Additionally, we employ proteomic and transcriptomic analyses such as Western blotting, immunofluorescence, real-time PCR, and digital PCR. Furthermore, we develop methods to transduce human primary keratinocytes using lentiviral or retroviral vectors, as well as CRISPR-based gene editing techniques. We developed clinical trials for the use of these cells in clinics. Additional information and full list of publication could be found here: https://www.cmr.unimore.it/en/homepage-2/

## Existing facilities that will be accessible and available to the doctoral candidate to conduct her/his research

The doctoral candidate will conduct her/his activities at the Centre For Regenerative Medicine “Stefano Ferrari” in the University of Modena and Reggio Emilia is a 3-floor building of 4.000 sq metres fully equipped for biochemistry, molecular biology, histology, cytology. Core facilities include confocal and time-lapse microscopy, laser microdissection, X-ray cell irradiation, bioinformatics support, flow-cytometry, 5 fully equipped BL2 cell culture rooms, single-cell transcriptomic platforms (Chromium X from 10X Genomics, Droplet digital PCR from Bio-rad, Tapestry from Mission Bio) and library preparation.

## Collaboration networks involving the research team

Our research team prides itself on its extensive collaboration networks, spanning across various academic disciplines and industry sectors. These networks serve as invaluable resources for doctoral candidates, offering unique opportunities for interdisciplinary exchange, access to cutting-edge technologies, and exposure to diverse perspectives.

Within academia, our team has established collaborations with national and international leading institutions and experts in fields closely related to the Futuredata4EU project. We collaborate with:

- Prof. Bicciato and Prof. Forcato at the University of Padua for the bioinformatic analysis.
- Prof. Paiardini and Prof. Rinaldo for protein structure prediction.
- Dott. Tommaso Selmi from Centro Nazionale delle Ricerche in Milano for epitranscriptomics analysis.
- The European partners in the Regenerate-IT consortium to share methods and tools related to the regenerative medicine field.
- Prof. Mariaceleste Aragona in ReNEW at Copenhagen to study the crosstalk between fibroblast and epithelial cells.

Through these connections, doctoral candidates gain access to specialized knowledge, methodological expertise, and collaborative research opportunities, enriching their academic experience and broadening their professional networks.

Furthermore, our team maintains strong ties with industry partners, including biotech companies (es Holostem s.r.l.), government agencies (es, EMA, Aifa), and non-profit patient organizations (es. Le ali di Camilla). These collaborations offer doctoral candidates real-world insights into the practical applications of their research, as well as opportunities for technology transfer, industry placements, and entrepreneurship initiatives.

## International and/or national and/or regional projects in which the research team is currently involved or has accessed through competitive calls, activated within the last 5 years, or set to start within 1 year

- Regenerate-IT Learning From Animals How To Regenerate: multidisciplinary training programme in regenerative biology - Marie Skłodowska-Curie Actions – Doctoral Networks (MSCA-DN), PI Michele De Luca
- Custom-designed gene editing of induced epidermal stem cells for gene therapy of genetic diseases of squamous epithelia (HOLO-GT)- - Holo-GT- ERC project, ERC-ADG- Advanced Grant - PI Michele De Luca
- Cellule staminali e medicina personalizzata: il caso della Epidermolisi Bollosa (HG7 3.0) - POR-FESR 2021-2027 PI Michele De Luca
- A plot in vitro and in vivo study for molecular characterization of epidermal stem cells and quality and safety assessment of epidermal cultures for combined cell and gene therapy – PRIN 2022 – PI Michele De Luca

- Gene-editing allele specifico mediato da CRISPR-Cpf1 ingegnerizzate per il trattamento delle patologie oculari nella sindrome da Ectrodattilia-displasia ectodermica-labiopalatoschisi (EEC) - Telethon: PI Michele De Luca
- A new strategic model for a sustainable development and maintenance of advanced therapies on the market- FISA-2022-00928 – PI Graziella Pellegrini
- The Empty Nose syndrome, investigations propaedeutic to in vivo studies – PRIN 2022 – PI Graziella Pellegrini
- High-resolution study of translational dynamics in human epithelial stem cells – PRIN 2022 – PI: Dott. Tommaso Selmi, CO-PI: Elena Enzo

Unravel fibroblast-epithelial crosstalk supporting keratinocytes self-renewal to improve skin graft production. Leo Foundation –PI Prof. Mariaceleste Aragona, Third part: Elena Enzo.

UNIVERSITÀ DI PARMA (UNIPR)

# A Radio-immune-genomic Approach and Big Data Integration to Identify Predictive Signatures for the Response to Immunotherapy in Solid Tumors

## Doctoral Position

**A Radio-immune-genomic Approach and Big Data Integration to Identify Predictive Signatures for the Response to Immunotherapy in Solid Tumors**

## Doctoral Programme

Translational Medical and Surgical Sciences

## Description of the doctoral position's main topic

Immune Checkpoint Inhibitors (ICIs) have prompted a paradigm shift in the treatment landscape of multiple cancer types achieving unprecedented results, although still in a limited subset of patients (ranging from 20 to 30%). Thus, the identification of patient- and tumor-specific biomarkers able to guide patient selection and clinical decision making is of paramount relevance. Current artificial intelligence (AI) models largely operate in the domain of a single modality, partly neglecting the overall clinical context, which inevitably reduces their potential. Integration of different data modalities may increase robustness and accuracy of prognostic and predictive models, bringing AI closer to clinical practice. AI approaches allow exploitation of high-dimension oncological data in research, being also capable of discovering novel patterns within and across modalities suitable for explaining differences in patient outcomes or treatment resistance. A large amount of biomarkers (genomic, epigenomic, transcriptomic, pathomic, immunomic, radiomic) related to IO's efficacy can be extracted with AI techniques across a wide variety of different cancer types, demonstrating the general applicability of the models.

The common theme of this project is based on the premise that tumor heterogeneity, and response to ICIs, can be untangled by a multidisciplinary strategy involving the integrated analysis of radiologic, immunophenotypic and genomic/transcriptomic clues.

In detail, the following research fields will be explored, with the ultimate aim to develop a multiomic profile endowed with the potential to provide a non-invasive approach to advanced cancer patients and predict the response to immunotherapy:

- Immunophenotypic analysis: definition of Tumor Immune Microenvironment (TIME) on tissue specimens; flow-cytometric analysis of peripheral blood immune cell subpopulations and ELISA immunoassay for soluble mediators at baseline and during treatment.
- Genomic and transcriptomic analysis: Next Generation Sequencing (NGS) and Nanostring technologies will be employed for molecular characterization using a DNA/RNA based assay.
- Radiomic analysis: Extraction of high throughput radiomic features from CT scans at baseline and during treatment.
- Bioinformatics analysis: AI methodologies (i.e. standard machine learning [ML] and deep learning [DL]), broadly divided into supervised (random forest, support vector machine), semisupervised (multiple-instance learning, graph convolutional network) and unsupervised (principal component analysis, k-means clustering) learning will be applied to our omics data.

In summary, our project aims to apply AI based analytic techniques in a standardized and nationally shared treatment setting for advanced cancers. The required cooperation between different professionals for obtaining an adequate development of the essential multimodal strategy leads to an overall improvement of assistance levels which translates in an enhanced delivered quality for the patients, perfectly integrating with the national healthcare system policy and with the purpose of the present Call.

## Sub-themes of the doctoral position's main topic (if any)

None

## Potential Supervisors

Marcello Tiseo, Nicola Sverzellati, Giovanni Roti

## Doctoral candidate's desirable skills and competences

***Scientific and technical skills***

Specialization in Oncology or in Genetics is a plus, but not essential. Previous research experience is a plus.

***Soft skills***

The candidate should be able to work independently, take initiative, adopt critical judgment and demonstrate ability to work in team. In particular, he/she should be open to the multidisciplinary approach needed to

realize this project. The project will include several network wide educational events and a secondment, for which travel, communication and social skills are required.

***Other skills***

Proficiency in written and spoken English is crucial. Knowledge of data analysis and statistics is essential.

## Description of the research group(s) in which the doctoral candidate will be integrated

Our project has been conceived drawing from a strong biological rationale, using innovative techniques to bridge the unmet need of predictive biomarkers of IO treatment efficacy in patients with advanced cancer. The availability of modern instruments and the recognized experience of the participating subjects in the field, clearly supply quality to the project and allow an easy transferability and applicability of the obtained results to daily clinical practice. Multidisciplinary collaborative approach is a central issue for building personalized oncology and for devising novel treatments. Accordingly, the idea originating the COFUND research project 'Futuredata4EU' comes from the urgent need of exploring, innovating, integrating, and validating existing and novel approaches in a new objective unified framework for enabling in the current clinical practice, patient-specific methods and tools for the intervention and the follow-up of personalized therapeutic strategies. The involvement of several operative units and departments from different institutions in this project strengthens an already well-established cooperative attitude. Our project provides the opportunity to share innovative multiomic analysis of blood and tissue samples, high throughput extracted imaging features thus favouring the diffusion of the related knowledge. Medical Oncology core: responsible for interaction between clinicians and laboratory team; involvement in patient accrual and screening, obtaining informed consent, patient management and assessing treatment outcomes. Radiology and Bioinformatics core: the Radiology team will focus on CT evaluations and extraction of radiomic features. The bioinformatic team will support AI-based analyses of multiomic data. Histopathology core: responsible for diagnostic and immunohistochemical (IHC) analysis, assessment of patient immune profiles. Immunobiology core: responsible for characterization of circulating immune profiling based on Fluorescence Activated Cell Sorting (FACS) and ELISA analyses. Genetic-molecular core: responsible for development of genetic-molecular design of the project, interaction between laboratory team and clinicians and the management of biological samples.

## Existing facilities that will be accessible and available to the doctoral candidate to conduct her/his research

The project will take place at the Medical Oncology Unit of the University Hospital of Parma which is a high volume clinical centre, provided by Phase I and clinical research trial units with dedicated nurses, project managers and available laboratories. The research/diagnostic laboratory (CoreLAB) at the University Hospital of Parma contains the following technologies/expertise: nucleic acids extractor (MagCore HF16 Plus, RBC Bioscience Corp.), NGS Library Prep workstation (Hamilton MicroLab STARlet), quality control of nucleic acid and libraries (Agilent 4200 TapeStation System), Real Time PCR (Life Technologies, Roche), digital droplet PCR (Bio-Rad), NGS instruments (Illumina MiSeq and NextSeq550Dx) and Ella Automated Immunoassay System (Bio-Techne). At the Pathology Unit a MagCore HF16 Plus (RBC Bioscience Corp.), two NGS instruments (MiSeq, Illumina and IonS5, Life Technologies) and Nanostring technology are available. The platform available for FACS analysis is a Becton Dickinson FACSCelesta flow cytometer with BV configuration, specifically dedicated to translational studies. The system operates with BD FACSDiva™ software, a collection of easy-to-use tools for flow cytometer and application setup, data acquisition and data analysis. The Research and Innovation Unit provides methodological and biostatistical expertise, study quality assurance and control and management of financial aspects. The Ethics Committee Secretariat offers timely support to researchers, speeding up the submission process and ensure regulatory compliance. In the highly qualified Unit, specifically trained personnel operate in compliance with Good Clinical Practice, by mean of Standard Operating Procedures. A team of biologists and bioinformaticians fully involved in research projects are available to embrace the PhD candidate and to support him/her.

## Collaboration networks involving the research team

To achieve the objectives of this project, a variety of techniques will be required. It is impossible for a single project leader to have in his/her laboratory the expertise necessary to perform complex interdisciplinary experiments. The increase in scientific interaction among the five cores of this project in the last four years has strengthened the goals of our current proposal, which are the foundation of the research planned here. Our ongoing funded projects have been mainly focused on the understanding of the mechanisms underlying inter- and intra-tumor heterogeneity and its impact on the clinical response to IO. The critical role played by genetic and immune pathways in cancer evolution and response to treatment and their non-invasive decoding by radiomics have helped us to formulate the new hypotheses of this COFUND research project.

Most importantly, the funded research has prompted the group to raise new questions concerning the biology of the cancer-immunity cycle and its translation into clinical ground. During our frequent meetings in academic and clinical contexts, it became apparent to all of us that our common interest in optimizing the treatment of solid tumors, which increasingly affect the overall population, would have served our purposes better if our different but complementary expertise and objectives would have been combined in an integrated multidisciplinary research project. On the basis of recent results obtained in our laboratories, the five core leaders and associates were in agreement and felt rather strongly about the possibility to uncover the underpinnings of the heterogeneous response to IO by multiomic strategies. This novel approach was perceived as a crucial point of departure in the present investigation. It is conceivable that the future doctoral candidate would benefit not only from the high level of individual expertise on each field of the project but also from the strong motivation of the entire research group driven by the potential achievement of practice changing results. Moreover, acquiring the knowledge on AI based big data analysis represents an actual almost inevitable skill favouring the future integration of the candidate in academic or clinical environments.

## International and/or national and/or regional projects in which the research team is currently involved or has accessed through competitive calls, activated within the last 5 years, or set to start within 1 year

- PRIN Granted Project (P.I. Prof. Sebastiano Buti – 2 years) – "LINking CHOLesterol hoMeostasis with immune-inflammatory profiles to predict immunotherapy efficacy in patients with metastatic renal cell carcinoma and non-small cell lung cancer: the LINCHOLM study"
- BANDO RICERCA FINALIZZATA 2021 (P.I. Prof. Marcello Tiseo, RF-2021-12374037 – 3 years
- "A Multiomic Approach to Identify Prognostic and Predictive Signatures in Advanced Non-Oncogene Addicted Non-Small Cell Lung Cancer (NSCLC) receiving Immunotherapy"
- University Granted Project (FIL-QI 2021, P.I. Prof. Marcello Tiseo – 2 years) – "Identification of Prognostic and Predictive Radio-Immune-Genomic Signatures in Small Cell Lung Cancer (SCLC) and Malignant Pleural Mesothelioma (MPM)"
- Region University Research Granted Project - FIN-RER 2020 - (P.I. Prof. Marcello Tiseo – 3 years) - "A multiomics approach to identify prognostic and predictive features of immunotherapy in solid tumors"

- AIRC Granted Project (P.I. Prof. Nicola Sverzellati, IG 2019, ID. 23606 - 5 years) - “A Radio-Immuno-Genomic Approach to Identify Prognostic and Predictive Models for the Response to Immunotherapy in NSCLC”.

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA | AREA RICERCA

FutureData4EU
Training Future Big Data Experts for Europe

## Thematic area 2 – Culture, Creativity and Inclusive Society

UNIVERSITÀ DI BOLOGNA (UNIBO)

Data Analytics and AI for supporting legislative assistance at WIPO: a neuro-symbolic approach

## Doctoral Position

**Data Analytics and AI for supporting legislative assistance at WIPO: a neuro-symbolic approach**

## Doctoral Programme

Law, Science and Technology

## Description of the doctoral position's general/main topic

The project should analyse the data science and AI techniques for supporting the legislative assistance process in WIPO using normative documents, including Member States legislation, in order to extract legal knowledge, classify the main rules in selected areas of the patent law domain, monitoring the evolution of the domestic laws in this sector, identify common patterns and generate benchmark provisions to provide support to the legislative advice work carried out at WIPO. Prediction of future needs is another important goal for anticipating the assistance requested by Member States and enhancing the efficiency of delivering such services. The analysis of the big data (including data and documents and relationships between them) has the aim to detect, measure and address WIPO policies in the light of the Member States legislation to have more success in the regulative enforceability of the WIPO requirements.

The project includes three main steps:

1. analysis of the literature and the state of the art, using the data and documents collected from WIPO and Member States. Clean and harmonizing the data/document is fundamental for avoiding bias, distortion, and undesirable discrimination effects. Akoma Ntoso OASIS standard XML is used for harmonization and data cleaning.
2. Model development for elaborating the data using data science and AI models and techniques. In this step, several techniques will be compared using hybrid and neuro-symbolic approaches (symbolic, sub-symbolic, and knowledge graph representation).
3. Developing of dashboard for visualizing the results using metrics, indexes, and benchmarking techniques to explain the results.

4. The project includes a period at least of 12 months in WIPO premises for making experiments in place, tuning the model, to evaluating the results with the end-users.

## Sub-themes of the doctoral position's main topic (if any)

None

## Potential Supervisors

Monica Palmirani, Rodríguez Doncel Víctor, Bart Verheij.

## Doctoral candidate's desirable skills and competences

***Scientific and technical skills***

- Good knowledge of Artificial Intelligence (AI) and Explainable AI (XAI)
- Familiarity with logic and formal reasoning methods
- Excellent analytical and problem-solving skills

***Other skills***

- Knowledge of legal reasoning and argumentation frameworks
- Experience with deontic logic and normative concepts
- Programming skills (e.g., Python)

## Description of the research group(s) in which the doctoral candidate will be integrated

The group is composed by several other PhD candidates, researchers and network of full professors.

## Existing facilities that will be accessible and available to the doctoral candidate to conduct her/his research

The University Library System offers collections of books, magazines, exam texts, databases on traditional and electronic media; and manages advanced bibliographic services, specialized for disciplinary fields, to support teaching and research. The System is divided into 27 libraries and over 75 access points with 6,000 reading places. The overall heritage consists of approximately 4,000,000 volumes of press, 43,000 paper periodicals, 43,000 online periodicals, 152,000 ebooks, dictionaries and encyclopaedias, 500 databases, over

8000 theses doctoral and degree courses, 80,000 teaching materials in digital format. Among the services available: online catalogues, consultation, loan local and inter-library, supply of documents, assistance and guidance in bibliographic research through tutorials and services online, digital library platforms for archiving and preserving digital documentation produced at the University. We have a room for the lectures and a room for the PhD candidates where they can share their knowledge with interdisciplinary discussions. Finally, we have the possibility to have the support of the cloud computing equipment from UNIBO data factory and CINECA.

## Collaboration networks involving the research team

"Law, Science and Technology" is an interdisciplinary international PhD programme that involves a network of about 20 universities in Europe and extra-EU (e.g., Stanford, University of Pittsburgh, La Trobe – Australia, etc.). It hosts MSCA-EJD PhD students.

We have a strong connection with the AI community thanks to the PNRR project "Future Artificial Intelligence Research (FAIR)".

We have a strong connection with CINECA thanks to the PNRR project on HPC (ICSC National Research Centre in High-Performance Computing, Big Data and Quantum Computing).

The topic of IPR is fundamental for supporting the digital transformation of society, emerging technologies (e.g., AI), the global research. Good IPR management supports the EU economy to compete with a robust framework where the shareability of knowledge and protection of intellectual rights are balanced for fair growth. WIPO will be involved intensively in the project.

## International and/or national and/or regional projects in which the research team is currently involved or has accessed through competitive calls, activated within the last 5 years, or set to start within 1 year

- ERC CompuLaw, Giovanni Sartor, Computational Judiciary System
- ERC HypermodeLex, Monica Palmirani, eLigilsation and AI
- JUST, FACILEX, Giuseppe Contissa, eJustice
- CERV, FAST-LISA, Francesca Curi, Hate Speech and Human Rights
- PON, Digital Twins, Antonino Rotolo, Smart Cities.

UNIVERSITÀ DI FERRARA (UNIFE)

# Unravelling the Evolution of Lithic Tools Morphology: Leveraging Big Data and Geometric Morphometrics in Archaeological Analysis

## Doctoral Position

**Unravelling the Evolution of Lithic Tools Morphology: Leveraging Big Data and Geometric Morphometrics in Archaeological Analysis**

## Doctoral Programme

Human Sciences

## Description of the doctoral position's general/main topic

The advent of big data has revolutionized various fields, including archaeology, by enabling the analysis of vast datasets to uncover hidden patterns and insights. In the realm of lithic analysis, geometric morphometrics offers a powerful approach to understanding the evolution of stone tool technology. Geometric morphometrics provides a framework for quantifying and analysing shape variation, allowing to explore the intricate morphological features of lithic instruments in unprecedented detail. By leveraging big data methodologies (statistical methodologies such as clustering and regression on larger datasets, aided by advanced tools), researchers can process large quantities of morphometric data collected from diverse archaeological sites, spanning vast temporal and geographical scales. This project will focus on the synergy between big data analytics and geometric morphometrics in unravelling the complexities of lithic tools (belonging to a specific chronological period – from Lower Palaeolithic to Neolithic - or representing a ubiquitous cultural innovation), shedding light on ancient hominin behaviour, cognitive abilities, and technological innovations.

The project fits into an international context constituted by the network of research centers focusing on prehistory. 36 institutions across Europe, Asia, Africa, and the Americas are already connected through the International Erasmus Mundus Master in Quaternary and Prehistory, and the development of this theme would represent an advancement in research methodologies (that can then be applied in a broader context generally to all cultural artifacts) in the cultural interpretation, of prehistoric artifacts. At the national and regional levels, the project will strengthen collaborations between museums and universities through the

implications for the museumization of lithic industries, which are often regarded as a non-speaking heritage and challenging to disseminate.

After conclusion, it opens a plethora of career opportunities for researchers specialized in merging cutting-edge technology with archaeology. Professionals adept in big data analytics, statistical methodologies, and geometric morphometrics are in high demand across academic, research, and industry sectors. Positions such as data scientists specializing in archaeology, research analysts focusing on cultural heritage, and specialists in digital archaeology are just a few examples of the diverse career paths available. Additionally, there are opportunities for collaboration with museums, cultural heritage institutions, and government agencies involved in archaeological preservation and research. Furthermore, this project lays the groundwork for interdisciplinary collaborations, offering avenues for archaeologists to collaborate with experts in computer science, data engineering, and machine learning. Overall, the skills and insights gained provide a solid foundation for pursuing a rewarding career at the forefront of archaeological innovation and data-driven research.

## Sub-themes of the doctoral position's main topic (if any)

None

## Potential Supervisors

Marta Arzarello, Marco Peresani, Federica Fontana.

## Doctoral candidate's desirable skills and competences

***Scientific and technical skills***

The candidate must necessarily possess the following skills:

- experience in using geometric morphometrics for contour analysis;
- knowledge of the technological approach to the study of lithic industries;
- understanding of human and cultural evolution throughout the Paleolithic;
- knowledge of basic statistics.

The following additional skills may be considered useful for carrying out the research project:

- Knowledge of the software R Studio;
- knowledge of the software Past;
- expertise in generative AI;

- ability to perform 3D scanning;
- knowledge of the fundamentals of Python programming;
- proficiency in at least two languages besides English;
- ability to structure a scientific article.

## Description of the research group(s) in which the doctoral candidate will be integrated

The involved research group deals with interdisciplinary studies (with expertise in prehistoric archaeology, geology, palynology, human and vertebrate paleontology, radiometric dating, fossil DNA, cultural heritage management, museology and museography) on prehistory from its early phases up to the Neolithic. The doctoral candidate will be integrated into an international research network that has been conducting interdisciplinary and joint research in the field of prehistoric archeology for more than 20 years.

The research group is based on the collaboration between the University of Ferrara (Italy), the Muséum national d'Histoire naturelle de Paris (France), the Universitat Rovira i Virgilli (Spain), and the Instituto Politecnico de Tomar (Portugal). These partners include collaborations with associated partners from Asia, Africa and South America. The connection between these institutions was made definitively official in 2004 (the year in which the joint Erasmus Mundus Master in Quaternary and Prehistory financed by the EACEA was opened, still active) and to date has seen the joint development of numerous research and training projects (see point 17).

Concerning the study of lithic industries, specifically, the research group is seeking to develop an innovative methodology that goes beyond a techno-economic approach and allows highlighting cultural trends within a “phylogenetic” perspective. However, this approach requires the collection and processing of a large amount of data, which must necessarily come from extensive geographical areas. The research group conducts excavations in Europe, Africa, and Asia (excluding the Americas due to their relatively recent human habitation), which will facilitate the collection of the dataset regardless of the specific research project presented by the candidate. From a methodological point of view, the PhD candidate will be supported by a large group of researchers involved in the ERC project “Why late earliest occupation of Western Europe?”. In this context, indeed, new approaches for interpreting lithic assemblages are being explored, approaches that include cladistics and geometric morphometrics. The latter requires the definition of a specific methodological protocol because there are no landmarks on lithic industries, thus contour analyses are necessary, which can only be performed on 3D models. At the local level, at the University of Ferrara, the research group within the section of Prehistoric and Anthropological Sciences possesses all the necessary

expertise, as its members span their expertise from the earliest European peopling to the latest Mesolithic hunter-gatherers. Additionally, the research group is conducting excavations at some of the key sites of utmost importance for defining the technical behaviors of Pleistocene Hominins: Pirro Nord, Grotta della Ciota Ciara, Riparo Tagliente, and Grotta di Fumane, to name a few of the most well-known ones.

## Existing facilities that will be accessible and available to the doctoral candidate to conduct her/his research

The environment in which the candidate will be welcomed will provide all the necessary equipment for conducting the research. At the Department of Humanities, the following equipment (already available) will be provided to the candidate:

- 3D workstation including a Breuckmann smartSCAN AICON 3D Systems that uses structured light technology. The smartSCAN 3D is versatile and perfect for use in various settings, making it particularly suitable for mobile or on-site applications. Its sensor setup enables scanning at triangulation angles of 30°, 20°, and 10°. This configuration enables precise measurement of even the most intricate object areas and geometries with exceptional detail.
- Equipped laboratory for creating 3D models through photogrammetry
- DELL workstation for Data Sciences.
- Lithic technology laboratory for the creation of a possible comparative collection (if necessary, within the scope of the presented project) and equipped with an extensive lithotheque.
- Transmitted and reflected light microscopes (if the presented project also involves the use wear analysis or the analysis of raw material procurement areas).
- Office, access to all online bibliographic resources, and a specialized library on prehistory. During the foreign mobility, at the Muséum national d'Histoire naturelle de Paris, additional equipment will also be made available.
- A KONICA MINOLTA RANGE 7Scanner, a measurement stand, a rotary table (acquisition and data processing software: RangeViewer and Geomagic Wrap).

- A Faro Edge ArmScanner from Faro, consisting of a measurement arm and a FaroBlu TM non-contact scanner (Geomagic Wrap software). This scanner is provided through a partnership with the NGO Global Digital Heritage.
- Access to the Distributed System for Scientific Collections (DiSSCo).

## Collaboration networks involving the research team

The international network involving the research team has been partially described at point 12 and supported by the common projects listed at point 17.

The network of national collaborations underlying the research stems from partnerships with colleagues from various Italian universities where prehistoric studies are particularly developed: the "Sapienza" University of Rome for paleontological aspects, the University of Trento for geoarchaeology and the later phases of prehistory, the University of Modena and Reggio Emilia for paleoenvironmental studies, and the University of Benevento for studies on the mineralogical characterization of raw materials.

An important role will also be played by collaborations with prehistory museums with which the team of researchers works closely and has curated part of the exhibitions: Borgosesia Paleontological Archaeological Museum, Pirro Nord Museum in Apricena, Civic Museums of Modena, Vittorino Cazzetta Museum in Selva di Cadore, Sant'Anna d'Alfaedo Paleontological and Prehistoric Museum, Isernia La Pineta Paleolithic Museum.

The collaborative network also includes some private companies that can contribute to the development of this research by providing their expertise in parallel but fundamental areas. The innovative company "Archeosmart s.r.l." (Italy), a spin-off of the University of Ferrara, will contribute to the dissemination of results and their application in the context of museum outreach. The company "HolyMoka Games" (France) will contribute to the development of Python programming.

Moreover, the candidate will be integrated into a peer context thanks to the presence, within the PhD program in Human Sciences at the University of Ferrara, of other PhD students focusing on themes related to prehistory. Specifically, they will be accompanied by PhD students who apply geometric morphometrics to the study of the evolution of brain internal structures and by those studying the technological aspects of lithic industries.

## International and/or national and/or regional projects in which the research team is currently involved or has accessed through competitive calls, activated within the last 5 years, or set to start within 1 year

The main projects in which members of the research group are involved are (non-exhaustive list due to character limitations):

- 610531-EPP-1-2019-1-IT-EPPKA1-JMD-MOB Erasmus+: Key Action 1 EMJMD. GA 2019-1462 International master in Quaternary and Prehistory - https://quaternaryprehistory.eu/- PI: Marta Arzarello
- ANR (Agence Nationale de la recherche) – AAPG2019 – ANR-19-CE27-0011. NEANDROOTS. Understanding a threshold in Human evolution at 450-350 Ka through the roots of Neanderthal behavior - https://sites.google.com/unife.it/nenandroots/home - PI: Marie-Hélène Moncel, involved members: Marta Arzarello
- 2023-1-FR01-KA220-HED-000153092 KA220-HED - Partenariats de coopération dans l'enseignement supérieur HERIT-AWARE « AWAREness and management of natural and cultural HERITage challenges: a skill acquired during university studies » - PI: François Sémah, MNHN - PI of the Ferrara' Research Unit: Marta Arzarello
- R2STAIR EH2020-MSCA-COFUND-2020 Programme, Grant agreement ID: 101034349 - https://cordis.europa.eu/project/id/101034349 - PI: Carlos Lorenzo (URV), involved members: Marta Arzarello & Marco Peresani
- ERC Advanced Grant 2021 LATEUROPE - Why late earliest occupation of Western Europe? - https://cordis.europa.eu/project/id/101052653 - PI: Marie-Hélène Moncel, involved members: Marta Arzarello & Paula Garcia Medrano
- Ecole Française de Rome « L'Italie paléolithique : peuplement et traditions techniques » - https://www.efrome.it/it/la-ricerca/assi-di-ricerca – PI : Marta Arzarello & Marco Peresani
- COST Project "Integrating Neandertal Legacy: From Past to Present" - https://inealcost.inantro.hr/ - PI of the Ferrara Research Unit: Marco Peresani

- PRIN 2022 “AFTER THE ICE - Forager Uses of "Persistent Places” in the Late Upper Palaeolithic of the Circum-Adriatic Region: Perspectives from the Riparo Tagliente (Verona, Italy) and Badanj (Bosniaand Herzegovina)” – PI: Federica Fontana.

Thematic Area 3 – Civil Security for Society

UNIVERSITÀ DI FERRARA (UNIFE)

# Enhancing Risk Prevention in Society: Advanced Mathematical Methods and Computer Science Techniques

## Doctoral Position

**Enhancing Risk Prevention in Society: Advanced Mathematical Methods and Computer Science Techniques**

## Doctoral Programme

Mathematics

## Description of the doctoral position's main topic

The PhD project will focus on developing advanced mathematical models and computer science tools for risk prevention in society, with a strong emphasis on leveraging big data techniques. This interdisciplinary project encompasses three main research themes: design of optimal response strategies, mitigating risk in epidemics, and prevention of cyber-attacks.

A first line of research encompasses the development of mathematical models and computational algorithms aimed at optimizing disaster response strategies. This includes but is not limited to, enhancing evacuation planning protocols, effectively allocating resources, and facilitating the coordination of emergency services. To achieve these objectives, stochastic optimization techniques such as consensus-based optimization (CBO) methods will be employed, leveraging their capacity to iteratively converge towards optimal solutions by aggregating information from multiple agents. Additionally, the use of machine learning approaches will play a pivotal role in capturing the complex dynamics inherent in disaster scenarios, enabling a more accurate representation of system behaviour.

The second direction of research involves the development of mathematical models to assess epidemic risk within communities, integrating principles of kinetic theory, epidemiology, and collective dynamics. This interdisciplinary approach aims to understand how disease transmission interacts with social connections, ultimately informing effective policy and control measures. By simulating various scenarios and interventions, the project will provide valuable insights into the spread of infectious diseases and the design of efficient preventive measures. Such research contributes to evidence-based policymaking, enabling

proactive strategies to mitigate epidemic risk and foster community-wide consensus on public health measures, thus enhancing overall disease control efforts.

The last research field considers the fact that modern industrial environments face not only the safety and security challenges arising from the convergence of Information Technology (IT) and Operational Technology (OT), but also the fact that there is no longer a single, enterprise-wide perimeter. To address such issues, one should analyze pros and cons of adopting in the industrial landscape the Zero Trust Architecture (ZTA), a strategy removing the assumption that connected devices within the enterprise borders should be trusted. The research will investigate the adoption of Next Generation Firewalls (NGFWs) and Digital Twins (DTs) in the edge-to-cloud continuum, also by defining and dynamically evaluating the trustworthiness of deployment environments.

The PhD project aligns with regional, national, and global efforts in disaster management, public health, and cybersecurity. It offers career opportunities in academia, government, and private sectors, focusing on enhancing societal resilience and security through interdisciplinary research.

## Sub-themes of the doctoral position's main topic (if any)

None

## Potential Supervisors

Lorenzo Pareschi, Giacomo Dimarco, Carlo Giannelli.

## Doctoral candidate's desirable skills and competences

***Scientific and technical skills***

For the first and second research directions the candidate should have some familiarity with partial differential equations and some elementary course of numerical analysis. The knowledge of programming languages such as Matlab, Python or Julia (but C/C++ or Fortran can be used as well) will help the candidate to advance especially in the first research topic.

For the third line of research, while it is not required that the candidate has previous experience within the cybersecurity research field, it is a requirement a good knowledge about basilar aspects of operating systems, networking, web applications, programming, and Linux administration.

## Description of the research group(s) in which the doctoral candidate will be integrated

The successful candidate will be hosted at the Department of Mathematics and Computer Science of the University of Ferrara and will be member of the Center for Modeling, Computing and Statistics (CMCS). The Department is a node of the Marie-Curie Doctoral Network DataHyking. In the following a brief description of the key members of the research group their main research interest and achievements. Lorenzo Pareschi is the Chair of Applied and Computational Mathematics at Heriot-Watt University, Edinburgh UK, and Professor of Numerical Analysis at the University of Ferrara. He obtained his Ph.D. in Mathematics from the University of Bologna. His primary research activities focus applied and computational mathematics, optimization, uncertainty quantification with a focus on hyperbolic and kinetic equations. He was recognized as a Nelder Fellow at Imperial College, London, UK, in 2015, a John von Neumann Professor at the Technical University of Munich, Germany, in 2019, and a Wolfson Fellow of the Royal Society in 2023. He is associate editor for several international journals, including Multiscale Modeling and Simulation and SIAM Journal on Scientific Computing. He has authored over 200 scientific publications and 5 books. Giacomo Dimarco received the Ph.D. degree in applied mathematics from the University of Ferrara. He is currently Professor in Mathematical Physics at the University of Ferrara. He was Assistant Professor at the University of Toulouse, France, from 2009 to 2013 and Associate Professor in numerical analysis from 2013 to 2021 in Ferrara. His primary research activities focus mathematical modeling, computational mathematics, kinetic theory, control and uncertainty quantification. He is Associate Editor of Journal of Computational Physics and Annali of the University of Ferrara. He is the Director of CMCS and next Director of the Department of Mathematics and Computer Science. Carlo Giannelli received the Ph.D. degree in computer engineering from the University of Bologna. He is currently an Associate Professor in computer science at the University of Ferrara. His primary research activities focus on Industrial Internet of Things, Digital Twin management, Software Defined Networking, Blockchain technologies, and cybersecurity in Industry 4.0. He serves on Editorial Boards of COMCOM and EURASIP JWCN. Carlo Giannelli is part of the Distributed Systems research group at the University of Ferrara, carrying out scientific research in various fields, such as Big Data, Cloud/Edge/Fog Computing, IoT in Industry 4.0 and Smart City environments, IT service management and opportunistic networking.

For more detailed information about the group's research activities and achievements, additional details can be found on the following web pages:

https://dmi.unife.it/en

https://www.unife.it/centri/centro/modeling-calculation-and-statistics-centre

https://ds.unife.it/

https://datahyking.eu

## Existing facilities that will be accessible and available to the doctoral candidate to conduct her/his research

The Department of Mathematics and Computer Science will provide all necessary equipment and computing resources necessary to conduct the research. In addition, the candidate will join the CMCS and the DTCS research teams.

CMCS is an interdepartmental research centre affiliated with the University of Ferrara, promoted by the departments of Mathematics and Computer Science, Economics and Management and Engineering. The centre involves several researchers from different Italian universities. The primary function of the CMCS is to carry out research in various disciplines, including applied mathematics, numerical analysis, scientific computing, computational fluid dynamics, machine learning and statistics. The final aim foresees the application of the scientific goals achieved to real and tangible problems, through the development and implementation of mathematical models and software. In addition, the centre is committed to organizing educational and public events, of a national and international nature, related to cultural, scientific, and technical innovation in the areas of expertise of the centre.

The Digital Twin and Cybersecurity (DTCS) research team (part of the Distributed System research team) at the University of Ferrara, aims at investigating, analysing, and experimentally validating Zero Trust techniques and the Digital Twin paradigm to prevent, identify, and counterattack cyber-attacks and cyber threats. The research DTCS team is focused on IoT devices and industrial environments, but the same solution can be validated within Smart Cities environments. In addition, the DTCS research team designs and develops innovative solutions aiming at exploiting the Blockchain technology in industrial environments, by exploiting state-of-the-art platforms such as Hyperledger Fabric, and by extending traditional solutions to provide innovative features, e.g., to allow the resiliency of industrial environments even if (partially) compromise by an attack.

## Collaboration networks involving the research team

The applied mathematical group has established structural and ongoing scientific collaborations with prestigious international research institutions such as CNRS and INRIA, the University of Toulouse, Nice, Rennes in France, Aachen, Kaiserslautern in Germany, Oxford, Edinburgh in UK, Shanghai in China, Courant, Madison, and Washington University in USA. The computer science group has also established structural and ongoing scientific collaborations with prestigious international research institutions such as the Florida Institute for Human & Machine Cognition (IHMC) of Pensacola, FL, USA and IBM TJ Watson Research Center in New York, NY, USA.

The DataHyking network involves six partner universities (Leuven, Nice, Aachen, Kaiserlautern, Rome, Ferrara) and is a European Doctoral Network with the aim to create a data-driven simulation framework for kinetic models of interacting particle systems. DataHyking is focused on developing reliable and efficient simulation methods, designing robust consensus-based optimization, also for machine learning, and developing multifidelity methods for uncertainty quantification and data assimilation. Applications involve traffic flow, finance, and granular flow, also in collaboration with industry. The PhD candidate will be fully involved in the network events and scientific collaborations.

The DTCS research team is involved in the EU 6G Smart Networks and Services Industry Association (6G-IA) https://6g-ia.eu/, providing the perspective of EU industry and research institutions on the next generation of networks and services. Its main objective is to contribute to the EU's leadership role in research areas related to 5G, 5G evolution, Smart Network Service (SNS) and 6G. 6G-IA carries out a wide range of activities in strategic areas including standardization, research and development projects, technological expertise, collaboration with key sectors of industry vertical markets, for trial development and for international cooperation.

## International and/or national and/or regional projects in which the research team is currently involved or has accessed through competitive calls, activated within the last 5 years, or set to start within 1 year

The candidate will join the DTCS research team to actively participate in several active funded projects carried on together with several other Italian and international universities.

***European Projects***

- "DATAHYKING - Data-driven simulation, uncertainty quantification and optimization for hyperbolic and kinetic models", HORIZON-MSCA-2021-DN-01-01 - MSCA Doctoral Networks 2021. University of Ferrara, KU Leuven, Roma La Sapienza, INRIA, University of Nice, University of Kaiserslautern, RWTH Aachen University. Lorenzo Pareschi scientific responsible for University of Ferrara.

***National projects***

- "Advanced numerical methods for time dependent parametric partial differential equations with applications", MIUR-PRIN 2022 project, Lorenzo Pareschi responsible of local unit.
- "Integrated Mathematical Approaches to Socio–Epidemiological Dynamics". PRIN 2020, Giacomo Dimarco responsible of the Research Unit. PNRR Future HPC & BIG DATA. Participants of the unit of the University of Ferrara.
- "IntelliGent and secure Networking in IndusTrial Environments: towards Industry 5.0 – IGNITE 5.0", PR-FESR 2021-2027 Regione Emilia Romagna, Carlo Giannelli responsible of local unit.
- "Cyber range for industrial security - CRI4.0", PR-FESR 2021-2027 Regione Emilia Romagna, Carlo Giannelli responsible of local unit.
- "Cybersecurity for Smart Industry - C4SI", PR-FESR 2021-2027 Regione Emilia Romagna, Carlo Giannelli responsible of local unit.
- "DATRUST - Connecting the physical and DigitAl worlds through TRUSTworthy dataflows", PRIN 2022 PNRR, Carlo Giannelli responsible of local unit.

Thematic Area 4 – Digital, Industry, Space

UNIVERSITÀ DI PARMA (UNIPR)

# Spin Systems for Quantum Technologies: advanced computing techniques, new concepts and realistic material simulations

## Doctoral Position

**Spin Systems for Quantum Technologies: advanced computing techniques, new concepts and realistic material simulations**

## Doctoral Programme

Physics

## Description of the doctoral position's main topic

Quantum computation (QC) is among the most rapidly growing technological fields, with the potential to greatly outperform existing computers on specific tasks. Spins represent prototypical quantum systems, and are the simplest objects where quantum mechanics can be framed and numerically simulated. In the context of quantum technologies, spins in solid-state systems are natural candidate elementary units (qubits) because of their relative decoupling from the environment and of their integration in a solid-state matrix, which eliminates the need to trap them optically or electromagnetically. Besides single spins, collective degrees of freedom resulting from coupled spins in nanostructures can be used to encode qubits or multi-level units (qudits). In particular, crystals of magnetic molecules are an excellent example, where the structure is chemically engineered in a bottom-up approach at the level of synthesis and whose properties can be changed to fit specific purposes. An alternative, or complementary, top-down approach is to assemble individual atomic or molecular spins on a surface, and control them by tips or external fields.

The candidate will exploit advanced computing techniques targeting many different aspects of such nanostructures which are relevant to their exploitation as elementary units of digital QC. These may include:

- The characterization of the Hamiltonian (e.g., ab-initio computational techniques like state-of-the-art density-functional-theory, DFT).

- The characterization of environment-induced decoherence due to phonons and/or nuclear spins (e.g., ab-initio DFT techniques; DFT-based machine learning force fields for spin-phonon couplings; large-scale simulations for systems of differential equations describing the open-system dynamics).
- The design of quantum control schemes –typically based on pulse sequences or quantum-circuit setups- driving the spins to perform specific tasks in quantum technologies, like quantum simulations or sensing (e.g., optimization of pulse sequences by conventional or machine-learning techniques, large-scale numerical simulations of the driven open-system dynamics).

The research will be carried out in the framework of many established connections with international groups. These include theoretical physicists (ab-initio calculations and quantum algorithms), chemists (synthesis of new molecules) and experimental physicists (characterization of the modeled systems and actual implementation of quantum algorithms). See below for more details.

At the end of the project the candidate will have acquired a solid background in digital quantum technologies and in large-scale computational techniques. Quantum technologies are a rapidly developing field, thus career opportunities will exist both within the academic and industrial sectors. The demand for specialists is quickly growing: almost all universities in the world have started or will soon start research and teaching activities on these topics, and many new corporate actors in the field are constantly emerging, ranging from small start-ups to large corporations. In addition, the significant competences in mathematical modeling and large-scale computations are a precious transversal skill which is highly-valued in a very broad range of companies.

## Sub-themes of the doctoral position's main topic (if any)

None

## Potential Supervisors

Paolo Santini, Alessandro Chiesa, Elena Garlatti

## Doctoral candidate's desirable skills and competences

***Scientific and technical skills***

Very good knowledge of quantum mechanics, good programming skills, and a good knowledge of physics of matter

## Description of the research group(s) in which the doctoral candidate will be integrated

The Spin-based Quantum Science group of the University of Parma has a consolidated activity on developing theoretical models for the quantum behaviour of spin systems at the atomic, molecular and supra-molecular level, and on their potential applications in quantum technologies, particularly quantum computation and simulation. Most of this research is carried out through the identification of suitable model hamiltonians for physical systems encoding qubits, the numerical simulation of the associated quantum behavior, and the design and optimization of control schemes inducing the desired dynamics, both in closed- and open-system setups. Hamiltonians and system-environment interactions for potential candidate qubits/qudits are obtained through information from ab-initio calculations, and from the interpretation of targeted experiments. Calculations are typically large-scale for the systems of interest. In addition, the group has a proprietary NMR laboratory where some of the control schemes mentioned above can be experimentally implemented and tested. The group has 17 members, including 4 permanent staff, and a large number of international collaborations. The group has obtained funding from several international and national competitive projects in the last years. For more detailed information about the group's research activities and achievements, additional details can be found on the following web pages: https://www.spinquantumscience.unipr.it/.

## Existing facilities that will be accessible and available to the doctoral candidate to conduct her/his research

Computational facilities: dedicated workstations, high-performance-computing cluster of the University of Parma https://www.hpc.unipr.it/dokuwiki/doku.php?id=calcoloscientifico:userguide, high-performance computing facility at Cineca https://www.cineca.it/en/hpc, Jülich supercomputing center https://www.fz-juelich.de/en/ias/jsc. Experimental facilities: proprietary NMR laboratory https://www.spinquantumscience.unipr.it/about-us/nmr-quantum-lab/328/.

## Collaboration networks involving the research team

The research team has a large number of collaborations with highly recognized international groups. These include theoretical physicists (ab-initio calculations and quantum algorithms), chemists (synthesis of new magnetic molecules), and experimental physicists (characterization of the modelled systems and actual implementation of quantum algorithms). We mention among the Theoretical physicists: E. PAVARINI (Forschungszentrum Jülich), A. LUNGHI (U. Dublin), I. TAVERNELLI (IBM Zurich), S. WIMBERGER (U. Parma),

D. ZUECO (U. Zaragoza); Chemists: A. PAINELLI (U. Parma), R. SESSOLI (U. Florence), R. WINPENNY (U. Manchester); Experimental physicists: R. BITTL (FU Berlin), L. DA COSTA PEREIRA (KU LEUVEN), F. LUIS (CSIC Zaragoza), M. WASIELEWSKI (Northwestern U.).

## International and/or national and/or regional projects in which the research team is currently involved or has accessed through competitive calls, activated within the last 5 years, or set to start within 1 year

***European Projects***

- "CASTLE (Chirality and Spin Selectivity in Electron Transfer Processes: from Quantum Detection to Quantum Enabled Technologies, Horizon Europe, GA 101071533). ERC-SyG, PI Stefano Carretta (Uni Parma). Role of the research team in the project: theoretical modeling, DFT calculations, numerical simulations, design of experiments on real systems, design of schemes of quantum technologies, NMR experiments.
- "Coherent addressing of isotopically pure lanthanide complexes by photons and efficient quantum error correction for Quantum Information Technologies". Novo Nordisk Foundation, grant NNF21OC0070832, call "Exploratory Interdisciplinary Synergy Programme 2021". PI: Stergios Piligkos (Uni Copenaghen), co-PI Stefano Carretta (UNIPR). Role of the research team in the project: theoretical modeling, numerical simulations, design of experiments on real systems, design of schemes of quantum technologies NMR experiments.

***National projects***

- NQSTI, National Quantum Science and Technology Institute. Consortium of universities and industries funded by the National Recovery and Resilience Plan, PI for Uni Parma Stefano Carretta (UNIPR). Role of the research team in the project: theoretical modeling, DFT calculations, numerical simulations, design of experiments on real systems, design of schemes of quantum technologies, NMR experiments.
- CROQUET (Molecular Dimers for Quantum Error Correction on the surface, PRIN national project). PI Lorenzo Poggini (CNR-ICCOM), co-PI Elena Garlatti (UNIPR). Role of the research team in the project: theoretical modeling, numerical simulations, design of experiments on real systems, design of schemes of quantum technologies NMR experiments.

Thematic Area 5 – Climate, Energy and Mobility

UNIVERSITÀ DI BOLOGNA (UNIBO)

# Combining Machine Learning and Computational Chemistry to explore the chemical space of functional materials

## Doctoral Position

**Combining Machine Learning and Computational Chemistry to explore the chemical space of functional materials**

## Doctoral Programme

Industrial Chemistry

## Description of the doctoral position's general/main topic

The proposed project will necessarily aim at combining computational chemistry (CC) to artificial intelligence / machine learning (ML) on target energy-related applications concerning photoactive organic materials (see subthemes) with a focus on the production and management of large amount of data (BD). Creating new molecules according to specific functional requirements has been the dream of chemists and industries for decades. Today, with the improvements of first-principle packages, AI, and hardware, this might be possible. The future of material research is for molecules to be pre-designed on a computer for fitting a specific purpose, more than checking their chemical-physical properties and then finding a role for them.

The challenges and the benefits of the approach have been nicely reviewed by Tkatchenko and coworkers (https://doi.org/10.1021/acs.chemrev.1c00107):

1. Reliance on ML in CC algorithms must be increased:
2. More general ML approaches are needed
3. ML representations must include the right physics
4. CC + ML applications need to strive toward achieving realistic complexity
5. Much more comprehensive data sets (BD) need to be assembled and curated
6. Bolder and deeper explorations of chemical space (BD) are needed.

The successful applicant is expected to contribute to the progress of the field along all these directions.

Just to make a few, non exhaustive examples, possible activities could be the development of:

1. digital platforms for the computational design of a certain class of molecules

2. AI-based generator models capable of cleverly proposing new molecular structures exploring the full chemical space of the targeted compounds.
3. automated workflows to predict with computational chemistry methods the physical properties of different candidate molecules in gas and liquid phase, and in solution.
4. automated algorithms for interrogating (data-mining) existing computational materials repositories (see e.g. https://cmr.fysik.dtu.dk/ https://docs.iochem-bd.org/ https://next-gen.materialsproject.org/ https://www.materialscloud.org/home https://cpd.chemcatbio.org/ https://www.catalysis-hub.org/ https://opencatalystproject.org/ ) or literature sources.
5. descriptors and standards for the representation of the chemical data, i.e. the database design.

These developments will be of interest for introducing digitalization (Industry 4.0) in several business sectors at the interface between chemistry, energy, and engineering, such as chemical companies implementing computational solutions for molecular design, and manufacturers producing and marketing the target technologies. Moreover, the project will advance the European scientific basis, and fostering its leadership and global role in the area of renewable energy, in this way supporting EU goals for climate protection, energy independence and economic growth.

## Sub-themes of the doctoral position's main topic (if any)

We singled out three possible subthemes / application fields which are of great interest for the researchers of the department of industrial chemistry:

1) Molecular solar thermal fuels (https://doi.org/10.1016/j.joule.2021.11.001): MOSTs are photoswitchable molecules that can store the energy from the sun ("Solar-to-X") and deliver it back as heat in a reversible way. These systems, upon light absorption, can interconvert from a thermodynamically stable isomer A into a higher energy metastable isomer B. The thermal or catalytic B->A back-conversion process can release a certain amount of heat (the energy difference between A and B photoisomers). If this heat release can be controlled, it can be exploited in several technologies, for instance for domestic heating, however materials and devices need further development to meet market requirements and the efficiency range achieved by current solar cells.

2) photoactivated artificial molecular motors (https://doi.org/10.1021/jacsau.3c00089): Here the focus, rather than in storing chemical energy for a later release, is the accurate control of long-range motion at the

molecular scale, which holds great but still unfulfilled potential for the development of ground-breaking applications in energy storage and bionanotechnology.

3) organic photoredox catalysis (https://doi.org/10.1021/acs.chemrev.6b00057): photocatalysis has become a powerful strategy for constructing extensive collections of biologically relevant molecules and complex natural products. Additionally, combining photocatalysis with other catalytic methods has provided novel transformations in the arsenal of organic and industrial chemistry. However, much work remains in developing photocatalysts with higher stability, activity, and performance, including exploring (or avoiding) metals and metal–ligand combinations, as well as novel organic chromophores.

## Potential Supervisors

Luca Muccioli, Ivan Rivalta, Marco Garavelli, Artur Nenov

## Doctoral candidate's desirable skills and competences

- Computational skills and a passion for computer science and modelling are a must, as the PhD will involve a significant amount of coding (mostly in Python).
- -experience in high performance computing and in ML/AI methods
- familiarity with basics of mainstream programming languages (e.g., C/C++, Fortran9X, Java, Python)
- -experience in molecular modelling
- good communications skills, scientific curiosity, and interest in interdisciplinary research

## Description of the research group(s) in which the doctoral candidate will be integrated

The SC2 group specializes in Computational Photochemistry, Photophysics and Spectroscopy of Photoresponsive Molecular Materials, and Computational Materials Science. This includes i) the development and application of computational tools for modelling accurate photoinduced dynamics of complex photoresponsive molecular systems in realistic conditions, including their underlying multi-pulse transient spectroscopies at various spectral regimes, spanning the NIR-VIS-UV-Xray spectral window ii) the characterization and analysis of photoactive molecular materials (from simple isolated molecules to biological photoreceptors and complex molecular architectures including environment effects) is employed for the design of novel and smart materials (e.g., photochromic systems, molecular switches, etc.) with tailored properties, encompassing a tunable photophysics and a controlled (photo)reactivity. iii) the prediction of structural, electronic, and chemical properties of functional materials, including organic soft

matter, biological systems and catalysts, through computer simulations (Molecular Dynamics, Metropolis and Kinetic Monte Carlo) methods, quantum chemistry calculations and network analysis.

## Existing facilities that will be accessible and available to the doctoral candidate to conduct her/his research

The computational chemistry group provides the required expertise of an array of quantum and classical calculation and simulations techniques, in computer programming, and the computational resources. The local computer center, fully dedicated to the computational chemistry unit, hosts most recent HPC clusters (~2000 cores) and computational chemistry software (Gaussian, Molcas, Molpro, Amber, NAMD, VASP, QuantumEspresso, etc.).

## Collaboration networks involving the research team

The group has established collaborations with the local experimental groups listed below, to not mention a large network of national and international collaborations:

- Center for Light Activated Nanostructures https://centri.unibo.it/clan/en
- Organic Catalysis Structural Analysis https://site.unibo.it/organic-catalysis-structural-analysis/en
- Catalysis for Renewable and Innovative Process "Care in Process" group: https://site.unibo.it/catalysis-for-renewables-and-innovative-processes/en
- Center for Chemical Catalysis https://centri.unibo.it/c3/en

## International and/or national and/or regional projects in which the research team is currently involved or has accessed through competitive calls, activated within the last 5 years, or set to start within 1 year

- GEM – GEtting the MOST out of the sun – IFAB foundation project https://www.ifabfoundation.org/ifab-activities/projects/gem-getting-the-most-out-of-the-sun/ PI Luca Muccioli
- SimDOME – Digital Ontology-based Modelling Environment for Simulation of materials – H2020. https://simdome.eu/ PI Marco Garavelli

Thematic Area 7 – Enabling Technologies

UNIVERSITÀ DI BOLOGNA (UNIBO)

Big Data handling in Next-generation Particle and Astroparticle Physics Experiments

## Doctoral Position

**Big Data handling in Next-generation Particle and Astroparticle Physics Experiments**

## Doctoral Programme

Data Science and Computation

## Description of the doctoral position's main topic

The Particle Physics and Astroparticle Physics program has achieved major advancements in fundamental physics, technology, and design of innovative computational tools and algorithms, resulting in landmark discoveries like the first observation of the Higgs boson at CERN in 2012 and the first detection of gravitational waves by LIGO and Virgo in 2015/2016. Future challenges require innovative software and computing solutions towards the physics mission.

Using CERN as an example, computing operations are managed through the Worldwide LHC Computing Grid (WLCG) project, a global collaboration spanning 170 computing centres across 40 countries. WLCG aims to provide global computing resources for storing, distributing, and analysing approximately 200 PB of LHC data annually. The High-Luminosity LHC (HL-LHC) project, a top priority since 2013, is slated to start in 2029, significantly increasing collision rates and enabling potential discoveries. For instance, HL-LHC is projected to produce a minimum of 15 million Higgs bosons yearly.

Significant investments are being made in experimental communities to prepare for the upcoming challenge. This includes enhancing the data acquisition pipeline to handle a broader range of collision events, as proton-proton collisions produce a diverse array of particles at a rate of 40 MHz. These events are tracked by radiation-hardened detectors and processed through multi-step "trigger" systems designed to rapidly select or reject data. Data collection throughput is crucial for identifying potentially significant signatures with confidence, a necessity that will only grow with the advent of HL-LHC.

The project of work of a COFUND "Futuredata4EU" scholarship will focus on software and computing tools as enabling technologies for extraction of insight from Big Data, towards an increased capacity to trigger and

record relevant data, hence facilitating the currently needed improvements to LHC data collection in Run-3, with the mindset to also look forward to future data collection needs, i.e. contribute to the following HL-LHC phases as well as providing critical insight to develop future detectors and data flows for even more ambitious objectives e.g. in the Future Circular Collider (FCC) and in the Einstein Telescope (ET) for gravitational waves detection, currently in their Feasibility Study phases.

Among the lines of work foreseen in this PhD project, the following can be mentioned:

- improve ML-assisted data collection (including simulations) and better leverage available (and new) computing infrastructures;
- develop data-driven, improved and accelerated algorithms and techniques (including AI-based) to filter out uninteresting events and filter in exotic interesting signatures at high speed and efficiency;
- contribute to the design and implementation of innovative AI-powered real-time processing workflow, with the ambitious goal to analyse every single collision produced in large-scale data-intensive experimental settings.

## Sub-themes of the doctoral position's main topic (if any)

None

## Potential Supervisors

Daniele Bonacorsi; Felice Pantaleo; Andrea Bocci

## Doctoral candidate's desirable skills and competences

***Scientific and technical skills***

- Familiarity with main concepts in experimental particle and/or astroparticle physics
- some experience in data acquisition and/or data analysis techniques
- programming skills, particularly in languages such as C++ and/or Python
- familiarity with statistical methods and machine learning frameworks
- ability to work effectively and independently in a collaborative research team
- excellent written and verbal communication skills.

***Other skills***

- previous involvement in large-scale experimental projects or collaborations
- advanced knowledge of experimental particle physics and/or astroparticle physics

- demonstrated experience with specific data handling tools and frameworks
- knowledge of distributed computing systems and parallel processing techniques
- familiarity with GPU programming and HPC systems

## Description of the research group(s) in which the doctoral candidate will be integrated

D. Bonacorsi is Full Professor in Experimental Physics at University of Bologna, working over the last 20 years on High Energy Physics (HEP) experiments at CERN. His research interests expanded to the design, deployment and operations of large-scale Software and Computing systems for data-intensive science. In the LHC community, he has been Offline and Computing coordinator for the CMS experiment at the LHC, he collaborates with major Data and Computing Centres in EU, US, Asia, and he has been among the pioneers of Machine/Deep Learning solutions in the HEP community. Dott. F. Pantaleo and Dott. A. Bocci are CERN staff scientists, have been covering leading roles in the Trigger of the CMS experiment at LHC since more than a decade, and in the adoption of deep learning techniques in CERN experiments, and are now deeply involved in designing and developing advanced solutions for next-generation triggers in HEP. The research group is complemented at University of Bologna by Dr. Carlo Battilana and Prof. Alessandra Fanfani, who are researchers with advanced software skills and ability to work in large collaboration on physics analysis, trigger studies and computing activities, by Dr. Tommaso Diotalevi, currently a NRRP-funded (National Recovery and Resilience Plan) RTDa researcher involved in physics-serving technology advancements and computing infrastructures, and a set of PhD researchers enrolled in the “Physics” PhD and in the “Data Science and Computation” PhD at University of Bologna. All UniBO colleagues listed above have a standing affiliation with the Italian INFN funding agency for HEP research, and all senior colleagues listed above have a demonstrated records of mentoring Bachelor and Master students, as well as PhD and postdoc researchers. The selected PhD candidate will be based in Bologna, although frequent visits to CERN as well as extended period of secondment at CERN or in other collaborating institutions is foreseen throughout the duration of the PhD programme. The research group is committed to maintaining an open and collaborative work environment that stimulates professional and personal growth of all members, and to fostering a diverse and inclusive research environment that welcomes individuals of all genders and ethnicities.

## Existing facilities that will be accessible and available to the doctoral candidate to conduct her/his research

The PhD candidate will have access to the research facilities of the DIFA department, and - for computing needs - to local CPU and GPU farms, both experiment-specific and multi-experiment, including the resources dedicate to the future astro-particle Einstein Telescope project.

The PhD candidate will be considered for affiliation to a CERN experiment, hence becoming a CERN user, able to access the CERN research facilities.

The PhD candidate will be supported to have access to the computational resources offered by NRRP-funded (National Recovery and Resilience Plan) national initiatives such as the "National Centre for HPC, Big Data and Quantum Computing" and the "Future AI Research" (FAIR) partnership.

If required and relevant, the PhD candidate will be supported to prepare a dedicated ISCRA project with the CINECA supercomputing centre, located in the Bologna Technopole, to take advantage of the high-performance computing facilities of the Leonardo supercomputer.

The overall area of the Bologna Technopole will offer additional chances for interdisciplinary collaborations on advanced technology research around Big Data challenges with colleagues from a variety of diverse disciplines and on a vast set of topics and applications - ranging from weather forecast to smart mobility solutions, from energy efficiency to hardware-oriented research, from digital twins to quantum computing research.

Finally, the Bologna Technopole will also offer a stimulating environment to be in contact with SMEs of the Emilia Romagna region, complementing the academic research with potential collaborations with industrial partners on topics of common interest, which will expand and fertilise the personal vision and professional skills of the PhD candidate.

## Collaboration networks involving the research team

The research team involving the FutureData4EU doctoral candidate is deeply embedded within extensive research collaboration networks, providing substantial added value to candidates. These networks span across academia and international research institutions, computing centres and data centres in Europe, US and Asia, in the network created by the World-wide LHC Computing Grid, fostering a rich environment for research collaborations and knowledge sharing. Within academia, in particular, our team collaborates closely

with renowned universities and research institutes worldwide, offering candidates opportunities for collaborative research, joint publications, and access to diverse expertise. This academic collaboration network facilitates exposure to cutting-edge research methodologies and enables candidates to engage with leading scholars in the field. Furthermore, strong ties in the Bologna Technopole with industry partners ensure that candidates gain practical insights into real-world applications of data science and Big Data challenges and solutions.

Overall, the collaboration networks involving our research team will provide the FutureData4EU doctoral candidates with a unique and enriching research experience, as candidates will have the opportunity to leverage these networks to expand their knowledge, develop valuable skills, and make meaningful contributions to the field on both a local and global scale.

## International and/or national and/or regional projects in which the research team is currently involved or has accessed through competitive calls, activated within the last 5 years, or set to start within 1 year

Internationally, the PhD candidate will be connected to large-scale CERN experiments and all related EU/US/national projects.

Nationally, the PhD candidate will be connected to NRRP-funded (National Recovery and Resilience Plan) initiatives, namely:

- "National Centre for HPC, Big Data and Quantum Computing", Mission 4, "Istruzione e Ricerca", Component 2, Investment 1.4, funded by the European Union - NextGenerationEU with an overall budget of about 320 MEuros, steered by the ICSC Foundation, whose President is Prof. Antonio Zoccoli (also INFN President and Full Professor at the University of Bologna)
- "Future AI Research" (FAIR) partnership, Mission 4, "Istruzione e Ricerca", Component 2, Investment 1.3, funded by the European Union - NextGenerationEU, with an overall budget of about 115 MEuros, which has WP whose activities are based in Bologna, with Prof. Michela Milano (Full Professor at the University of Bologna) as PI.