

Presentation of the doctoral module “The Craft of Scientific Research”

Course Description

Title:	The Craft of Scientific Research
Type:	Hybrid course of 6 credits
Methods of coverage:	Online lectures + two face-to-face tutorials
Credits	6
Teaching hours	150 of which 36 (frontal) + 114 self-studying on two projects
Assessment methods	Pass after the approval of two reports
Teaching period	from 17-01-2025 to 07-03-2025
Course year	1 st
Learning outcomes	The module formalises a large body of transferable skills related to scientific research that can be used throughout the research career in Italy and abroad.
Teaching resources:	https://virtuale.unibo.it/course/view.php?id=67066
To register:	https://virtuale.unibo.it/course/view.php?id=67066
Virtual classroom:	To attend, access this Microsoft Teams virtual classroom .

Abstract

The craft of Scientific Research focuses on a set of transferable skills that are deemed essential for the practice of scientific research. The first part of three lectures focuses on the fundamental concept of scientific truth and how humanity pursues it: Why do we need to know? What is a model? How do we know? Then we deliver a long list of “how to” lectures: How to choose a research topic, How to write and publish a scientific paper, How to review a paper or a grant, How to give a scientific presentation, How to do research, How to build and run a research group, and How to write a grant application. Grant writing and peer reviewing will also be the subject of two tutorials and two individual projects; their completion will be required to pass the exam. The delivery is hybrid: all frontal teaching will be done online, but the two tutorials require physical attendance.

Tentative calendar

Num.	Title of the lecture	Time	Date
Lect1	Intro + why do we need to know	09:00 - 12:00	17/01/2025
Lect2	What is a model? An evolutionary perspective	09:00 - 12:00	22/01/2025
Lect3	How do we know? The foundation of decision-making	09:00 - 12:00	24/01/2025
Lect4	How to choose a research topic	09:00 - 12:00	29/01/2025
Lect5	How to do research	09:00 - 12:00	31/01/2025
Lect6	How to write and publish a scientific paper	09:00 - 12:00	05/02/2025
Lect7	How to review a paper or a grant	09:00 - 12:00	07/02/2025
Lect8	How to give a scientific presentation	09:00 - 12:00	12/02/2025
Lect9	How to build and run a research group	09:00 - 12:00	14/02/2025
Lect10	How to write a grant application	09:00 - 12:00	19/02/2025
Lect11	Tutorial on peer reviewing	13:00 - 16:00	19/02/2025
Lect12	Tutorial on grant writing	13:00 - 16:00	07/03/2025

Detailed teaching program

Lecture 1: Intro + Why do we need to know (17/01/2025)

We discuss the need for humans to know. After briefly mentioning some philosophical and psychological perspectives, we discuss such needs from an evolutionary point of view. We then reflect on the many ways humans use to know, among them the logico-deductive approach at the foundation of scientific knowledge. Last, we discuss the motivations of a PhD student toward knowledge as their career develops, using my own winding career as a narrative example.

Lecture 2: What is a model? An evolutionary perspective (22/01/2025)

“What is a model? An evolutionary perspective” is a lecture I have been offering as a seminar for PhD students and postdocs for several years. Starting from the human need to know, we try to answer an apparently simple question: “What is a scientific model?”. Though a journey that again touches philosophy, neuroscience, and evolution theories, we arrive at an operational definition. Then, we tackle the issue of the credibility of models, both in fundamental and applied research. We conclude with some story-telling about modelling in science.

Lecture 3: How do we know? The foundation of decision-making (24/01/2025)

In this lecture, we explore how humans make decisions, particularly deciding whether a statement is true or not. After a general philosophical framing, we will focus on the scientific method and show how the two statistical inference theories (frequentist and Bayesian) are the root of profound epistemological differences between social and physical sciences. We translate this reflection on the foundational process of assessing the credibility of predictive models in science from the perspective of physical sciences and from that of medical sciences.

Lecture 4: How to choose a research topic (29/01/2025)

After a general reflection on the two purposes of scientific research (to increase humanity's knowledge and solve humanity's problems), we review some current opinions on choosing falsifiable research questions. Then, I took my own research trajectory, during which I authored or co-authored over 400 papers and reflected on why I chose that research topic over others. I identify 13 different motivations, which I critically discuss using my career as an example.

Lecture 5: How to do research (31/01/2025)

This is the central lecture of the whole course. We define what scientific research is, and then we discuss how research walks the whole pyramid of knowledge, from the observation of signals into data, their annotation into information, the uplift of information into tentative knowledge, and the complex step toward *wisdom*, the knowledge that resisted extensive falsification attempts and can be used for decision-making. Then, we discuss the difference between basic and applied research.

Lecture 6: How to write and publish a scientific paper (05/02/2025)

This is another lecture I have offered for many years as a seminar. After a historical excursus on why scientific papers eventually adopted the IMRAD structure that is now in use, I offer practical, operational advice on how to write a research paper section by section. I then briefly reflect on the crisis of scientific publishing, predatory and quasi-predatory journals, green open access, and the growing importance of open access for data.

Lecture 7: How to review a paper or a grant (07/02/2025)

A central tenet of scientific research is peer-reviewing. Every publication and every grant application you submit must be reviewed by other researchers who are experts in the specific field (peers). We discuss seven general and ten operational golden rules for the paper review. Concerning grant reviewing, we discuss quality, integrity and merit, conflicts of interest, review models, and the eight central steps of this kind of review.

Lecture 8: How to give a scientific presentation (12/02/2025)

This is another lecture that I have been offering to doctoral students as a seminar for years. We review the art of public speaking with specific reference to the presentation to peers, as it occurs in scientific conferences. We cover the story framing, the delivery planning, the stage presence, the multimedia aspects, and some practical aspects of presenting at large conferences.

Lecture 9: How to build and run a research group (14/02/2025)

Probably the most challenging aspect of our profession is the human factor, the complex process through which individuals become an operationally effective group. We will discuss leadership styles, vision and strategy, planning and funding, recruitment and team building, communication, etc.

Lecture 10: How to write a grant application (19/02/2025)

This will be a two-voice lecture with Alessia di Sandro, responsible for our university's Research Development Life Sciences & Bioeconomy sector. I will lecture on the five key steps toward successful grant applications. Then, my co-lecturer will get into the details of transforming a research idea into a grant application.

Tutorials

The module includes two in-person tutorials. The first (19/02/2025) is a tutorial on peer reviewing; the second (07/03/2025) is on grant writing. From 13:00 to 16:00, all students taking this module must attend the tutorials and produce relative elaborates. The rooms will be announced when the teaching calendar for the second semester is available.

Credits

According to the AVA3 criteria for doctoral teaching, the module is worth six credits. There is no exam, but to pass the module and receive the credits, each student must attend the frontal lectures and the two tutorials and produce the two elaborates required for such tutorials. Since, for this year, AVA3 doctoral teaching is still experimental, when such conditions are satisfied, the students can request a certification that documents they successfully passed directly to the lecturer.

Virtuale

The module is on Virtuale at the link below; you will find a copy of all slides used during the module and any other teaching material. Please register to receive communications about the rooms and any variation to the calendar: <https://virtuale.unibo.it/course/view.php?id=67066>

Descrizione del Corso (Italiano)

Titolo	The Craft of Scientific Research
Tipologia	Corso ibrido di 6 crediti
Lingua	Inglese
Modalità di copertura	Lezioni frontali online + due tutorial in presenza
Crediti	6
Ore didattica	150 di cui 36 (frontale) + 114 studio autonomo su due progetti
Modalità di verifica	Idoneità previa approvazione due elaborati
Periodo di erogazione	dal 17-01-2025 al 07-03-2025
Anno di corso	1°
Obiettivi formativi	formalizzazione di un ampio corpo di saperi “trasferibili”, competenze che possono essere usate durante tutta la carriera di ricercatore, in patria e all'estero.