COURSE DESCRIPTION

Pseudoscience in Chemistry and Biochemistry

Academic year 2025-2026

1. Programme-related data

1.1. Higher Education Institution	Babeș-Bolyai University, Cluj-Napoca
1.2. Faculty	Chemistry and Chemical Engineering
1.3. Department	Doctoral School of Chemistry
1.4. Field	Chemistry
1.5. Level of study	Doctorate
1.6. Degree programme / Qualification	Doctorate / Doctor in Chemistry
1.7. Form of education	Full time

2. Course-related data

2.1. Course title	***Pseudoscience in Chemistry and Biochemistry***			Course code	**SDC-19-14**
2.2. Course coordinator	Prof. Dr. Radu Lucian SILAGHI-DUMITRESCU				
2.3. Seminar coordinator	Prof. Dr. Radu Lucian SILAGHI-DUMITRESCU				
2.4. Year of study	**1**	2.5. Semester	**2**	2.6. Type of assessment	**Exam**
2.7. Course status	**Optional**	2.8. Course type	**Specialisation subject**		

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	**3**	of which: 3.2. course	**2**	3.3. seminar/ laboratory/ project	**1**
3.4. Total of hours in the curriculum	**36**	of which: 3.5. course	**24**	3.6. seminar/ laboratory	**12**

Time allocation for individual study (IS) and self-taught activities (ST)	**hours**
Learning from textbooks, course materials, bibliography, and notes (IS)	60
Additional research in the library, on subject-specific electronic platforms, and on-site	60
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays	50
Tutoring (professional guidance)	20
Examinations	20
Other activities	4
3.7. Total hours of individual study (IS) and self-taught activities (ST)	**214**
3.8. Total hours per semester	**250**
3.9. Number of credits	**10**

4. Prerequisites (where applicable)

4.1. curriculum-related	Master's-level training in chemistry, biochemistry, or a related discipline.
4.2. skills-related	Basic familiarity with the scientific method; reading-level English; critical reading skills.

5. Specific conditions (where applicable)

5.1. course-related	Students attend lectures having read the assigned material beforehand; mobile phones off or silent; active participation in debate.
5.2. seminar/laboratory-related	Students attend the seminar prepared with notes and the week's assigned readings; respectful, evidence-based participation in critical-analysis debates.

6.1. Competencies resulting from the completion of the degree programme

Professional competencies	
Competency code	**Competency**
PC1	Definition of notions, concepts, theories and advanced models in the field of Chemistry as well as their proper use within the professional community
PC4	Use of in-depth knowledge of chemistry to explain and interpret tools and processes specific to the critical analysis of chemical and biochemical claims
PC5	Identifying and applying advanced concepts, methods and theories to solve problems specific to evaluating scientific vs. pseudoscientific claims in chemistry and biochemistry
Transversal competencies	
Competency code	**Competency**
TC2	Execution of the requested tasks according to the specified requirements and within the imposed deadlines, in compliance with the norms of professional ethics and moral conduct, following a pre-established work plan
TC3	Solving the requested tasks in accordance with the general objectives established by integration within a working group

6.2. Learning outcomes relevant to the degree programme (as referred to in the curriculum)

Learning outcomes targeted by the subject		
Competency code	**Knowledge and comprehension**	**Specific academic skills**
PC1	Advanced and up-to-date knowledge in chemistry and biochemistry, including the demarcation problem and the history of pathological science; critical understanding of the scientific literature and of popular-science sources.	Applies and synthesizes advanced concepts to distinguish legitimate from pseudoscientific claims; justifies the choice of scientific benchmarks used for evaluation.
PC4	Advanced research methodologies: experimental design, modern synthesis and characterization techniques, analysis and validation; principles of research project management and of evidence hierarchy (anecdote, case series, RCT, meta-analysis).	Designs, plans and implements a small critical-analysis project; applies quality and safety procedures and documents stages and data with full traceability.
PC5	Advanced strategies for data analysis, interpretation, and integration; evaluation of methodological limitations, reproducibility, and	Critically analyses complex data, estimates uncertainty and formulates conclusions;

	scientific impact; understanding of the replication crisis and common failure modes.	proposes methodological improvements and directions for research/innovation.
TC2	Scientific terminology and communication in Romanian and English; the structure of scientific articles and public-communication pieces; good citation practices and the handling of uncertainty in communication.	Writes and presents scientific results in Romanian/English coherently; provides well-argued responses to comments and peer reviews.
TC3	Digital tools for research, citation, and data processing (databases, specialized software, reference managers, Retraction Watch); responsible use of digital resources.	Uses discipline-specific digital tools effectively; manages citations; uses digital resources responsibly in research and science-communication activities.

7. Subject-specific learning outcomes

Knowledge and comprehension
1. Applying the demarcation criteria and the symptoms of pathological science to classify claims encountered in chemistry and biochemistry
2. Ability to understand and interpret the biochemistry and chemistry underlying common pseudoscientific claims (homeopathy, detox, alkaline diet, structured water, antioxidant megadoses, chemophobia)
3. Critical analysis and use of advanced methods for the quantitative and qualitative evaluation of chemistry- and biochemistry-themed product and media claims
4. Awareness of the main research-integrity failure modes (p-hacking, HARKing, fraud, predatory publishing) and of the regulatory landscape (FDA, EMA, EFSA, EU Novel Food)
Specific academic skills
1. Execution of critical-analysis tasks according to specified requirements and within deadlines, in compliance with professional ethics (honest representation of evidence, explicit acknowledgement of uncertainty)
2. Concern for improving results by active engagement in debates and peer-review of classmates' rebuttals
3. Ability to prepare written rebuttals and to publicly defend them in a colloquium setting

8. Contents

8.1. Course		
Course/ Seminar topic	**Teaching and learning methods**	**Remarks**
8.1.1. Introduction: What is science; what is pseudoscience? Demarcation criteria (Popper, Kuhn, Lakatos). Langmuir's symptoms of pathological science (1953).	Presentation; Explanation; Conversation; Description; Debate	
8.1.2. Historical perspective: alchemy vs. chemistry; the phlogiston-to-oxygen transition; how superseded theories differ from pseudoscience; birth of modern chemical method.	Presentation; Explanation; Conversation; Description; Debate	
8.1.3. Historical case studies in pathological science: N-rays (Blondlot, 1903), polywater (Deryaguin et al., 1960s), cold fusion (Fleischmann & Pons, 1989); common sociological and cognitive patterns.	Presentation; Explanation; Conversation; Description; Debate	
8.1.4. Homeopathy: dilution chemistry and the Avogadro limit; C-scale and D-scale potencies; succussion; the "memory of water" and the Benveniste affair (1988); current regulatory status in the EU and worldwide.	Presentation; Explanation; Conversation; Description; Debate	

8.1.5. Detox / cleanse chemistry and the alkaline-diet myth: hepatic phase-I/phase-II metabolism and renal clearance; blood-buffer chemistry and the Henderson-Hasselbalch equation; gastric pH and bicarbonate buffering; why dietary pH cannot shift systemic pH.	Presentation; Explanation; Conversation; Description; Debate	
8.1.6. "Structured water" claims: EZ (exclusion-zone) water, hexagonal water, deuterium-depleted water, clustered water; what water can and cannot do at the molecular level.	Presentation; Explanation; Conversation; Description; Debate	
8.1.7. The antioxidant myth: reactive-oxygen-species biology, the antioxidant paradox, clinical trials of vitamin E/C/β-carotene, and why megadose supplementation can be harmful.	Presentation; Explanation; Conversation; Description; Debate	
8.1.8. Chemophobia: "chemical-free" marketing, natural-vs-synthetic fallacy, dose-response (Paracelsus), toxicity of natural compounds (ricin, botulinum, aflatoxins); teaching toxicology to counter chemophobia.	Presentation; Explanation; Conversation; Description; Debate	
8.1.9. Miracle cures: MMS / chlorine dioxide, ORMUS / monatomic-gold claims, colloidal silver, hydrogen water, "effective microorganisms"; chemistry of the claim vs. chemistry of the product.	Presentation; Explanation; Conversation; Description; Debate	
8.1.10. Nutraceutical and supplement pseudoscience: orthomolecular medicine and the Pauling vitamin-C story; adaptogens; "superfoods"; the evidence hierarchy from anecdote to RCT.	Presentation; Explanation; Conversation; Description; Debate	
8.1.11. Pseudoscience in biochemistry and molecular biology: blood-type diet, "epigenetic" lifestyle products, unvalidated peptide therapies, misuse of biochemistry terminology in marketing.	Presentation; Explanation; Conversation; Description; Debate	
8.1.12. Research-integrity failure modes and countering pseudoscience: the replication crisis; p-hacking, HARKing, publication bias; major fraud cases; critical reading of "chemistry" claims in media and advertising; regulatory frameworks (FDA, EMA, EFSA, EU Novel Food); effective science communication and audience trust.	Presentation; Explanation; Conversation; Description; Debate	

Bibliography

1. Langmuir, I. (1989). "Pathological Science" (transcript of a 1953 colloquium). Physics Today, 42(10), 36-48.

2. Park, R. L. (2000). Voodoo Science: The Road from Foolishness to Fraud. Oxford University Press.

3. Shermer, M. (2011). The Believing Brain. Times Books.

4. Ernst, E. (2018). Homeopathy: The Undiluted Facts. Springer.

5. Taubes, G. (1993). Bad Science: The Short Life and Weird Times of Cold Fusion. Random House.

6. Goldacre, B. (2008). Bad Science. Fourth Estate.

7. Ritchie, S. (2020). Science Fictions: How Fraud, Bias, Negligence, and Hype Undermine the Search for Truth. Metropolitan Books.

8. Ioannidis, J. P. A. (2005). "Why Most Published Research Findings Are False." PLoS Medicine, 2(8), e124.

9. Hansson, S. O. (2017). "Science and Pseudo-Science," in Stanford Encyclopedia of Philosophy (Zalta ed.).

10. Kauffman, G. B., Kauffman, L. M. (1990). "Polywater: An early 20th-century scientific artefact." J. Chem. Educ. 67(9), 732-735.

11. Pigliucci, M. (2010). Nonsense on Stilts: How to Tell Science from Bunk. University of Chicago Press.

12. Silaghi-Dumitrescu, R (2021). Measuring pseudoscience in online media: a case study on Romanian websites. Journal of Romanian Studies, 2, 111-128.

13. Silaghi-Dumitrescu, R. (2023). Trends in the texts of national anthems: a comparative study. Heliyon, e19105. https://doi.org/10.1016/j.heliyon.2023.e19105.

14. http://www.romaniacurata.ro/fara-dovezi-materiale-pentru-diluarea-de-zece-ori-a-dezinfectantilor-hexi-pharma/

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20. https://www.contributors.ro/cum-tac-universitatile-din-romania-despre-vaccinare/

8.2. Seminar/ laboratory

Course/ Seminar topic	Teaching and learning methods	Remarks
8.2.1. Close reading of Irving Langmuir's 1953 lecture on pathological science; students extract a personal "warning-flag" checklist.	Conversation; Learning by discovery; Problem solving; Critical reading	
8.2.2. Case-study workshop: N-rays. Reconstructing Blondlot's experimental setup and Wood's debunking; what controls were missing.	Conversation; Learning by discovery; Problem solving; Critical reading	
8.2.3. Dilution mathematics: computing molecular counts for 6C, 12C, 30C, 200C homeopathic dilutions; comparing with Avogadro's number.	Conversation; Learning by discovery; Problem solving; Critical reading	
8.2.4. Product-label audit: students bring one commercial "detox" or "cleanse" product and deconstruct the biochemistry claims; Henderson-Hasselbalch exercises on alkaline-water claims.	Conversation; Learning by discovery; Problem solving; Critical reading	
8.2.5. Critical reading of "EZ water" / Pollack claims: reading a primary paper and identifying methodological and thermodynamic issues.	Conversation; Learning by discovery; Problem solving; Critical reading	
8.2.6. Antioxidant meta-analyses: reading Bjelakovic et al. (2007/2012), discussing confidence intervals and heterogeneity.	Conversation; Learning by discovery; Problem solving; Critical reading	
8.2.7. "Chemical-free" supermarket sweep: classifying product claims along a spectrum from legitimate to misleading to false.	Conversation; Learning by discovery; Problem solving; Critical reading	
8.2.8. MMS, ORMUS, colloidal silver: reviewing FDA/EMA warning letters and the chemical impossibility of the central claim.	Conversation; Learning by discovery; Problem solving; Critical reading	
8.2.9. Megadose vitamin-C clinical trials: timeline from Pauling's 1970s claims to modern Cochrane reviews.	Conversation; Learning by discovery; Problem solving; Critical reading	
8.2.10. Blood-type-diet meta-analysis (Cusack et al. 2013): evaluating an exemplar epidemiological rebuttal.	Conversation; Learning by discovery; Problem solving; Critical reading	
8.2.11. Retraction Watch exercise: each student picks a retracted chemistry/biochemistry paper and presents a root-cause analysis; one-page plain-language rebuttal workshop.	Conversation; Learning by discovery; Problem solving; Critical reading	
8.2.12. Final presentations: students defend their rebuttal essays in a short colloquium, responding to questions and counterarguments.	Conversation; Learning by discovery; Problem solving; Critical reading	

Bibliography

1. Benveniste, J., Davenas, E., Beauvais, F., et al. (1988). "Human basophil degranulation triggered by very dilute antiserum against IgE." Nature 333, 816-818; and Maddox, Randi, Stewart (1988). "High-dilution experiments a delusion." Nature 334, 287-290.

2. Bjelakovic, G., Nikolova, D., Gluud, L. L., Simonetti, R. G., Gluud, C. (2012). "Antioxidant supplements for prevention of mortality in healthy participants." Cochrane Database of Systematic Reviews.

3. Cusack, L., De Buck, E., Compernolle, V., Vandekerckhove, P. (2013). "Blood type diets lack supporting evidence: a systematic review." Am. J. Clin. Nutr. 98(1), 99-104.

4. NCCIH (2017). "Detoxes and Cleanses: What You Need to Know." National Center for Complementary and Integrative Health, NIH.

5. Retraction Watch database (retractionwatch.com) — selected cases.

6. EFSA and FDA warning letters and enforcement actions on MMS (chlorine dioxide), colloidal silver, and ORMUS products.

9. Evaluation

Type of activity	9.1 Evaluation criteria	9.2 Evaluation methods	9.3 Percentage in the final grade
9.4. Course	Correctness of answers — proper understanding and learning of notions and concepts discussed during lectures; correct use of learned concepts within new contexts. Correct solving of the problems as part of the examination subjects.	Written report with critical analysis of a chosen case	**50%**
9.5. Seminar/ laboratory	Correctness of answers — proper understanding and learning of notions and concepts discussed during seminars; correct use of learned concepts within new contexts. Quality of reports, and quality of the final oral defense.	Final oral colloquium with defense of rebuttal essay	**50%**
9.6 Minimum standard for passing Adequate knowledge of at least one case study per major module (history/homeopathy/detox/antioxidants/chemophobia/research-integrity); demonstrated ability to construct an evidence-based rebuttal.			

10. SDG labels (Sustainable Development Goals)

(Select a single SDG label that best matches the subject; if none applies, select "No label applies". The Quality Education label has been selected for this course.)

☐ **1** No Poverty	☐ **2** Zero Hunger	☐ **3** Good Health and Well-being	☒ **4** Quality Education	☐ **5** Gender Equality	☐ **6** Clean Water and Sanitation	☐ **7** Affordable and Clean Energy	☐ **8** Decent Work and Economic Growth	☐ **9** Industry, Innovation and Infrastructure
☐ **10** Reduced Inequality	☐ **11** Sustainable Cities and Communities	☐ **12** Responsible Consumption and Production	☐ **13** Climate Action	☐ **14** Life Below Water	☐ **15** Life on Land	☐ **16** Peace, Justice and Strong Institutions	☐ **17** Partnerships for the Goals	☐ — No label applies

Date of entry:	**Signature of course coordinator**	**Signature of seminar coordinator**
21.04.2026	.....	.....

	Prof. Dr. Radu Lucian SILAGHI-DUMITRESCU	*Prof. Dr. Radu Lucian SILAGHI-DUMITRESCU*
Date of approval in CDSC: ……	**Signature of the Director of the DSC** …… *Prof. dr. Niculina Daniela Hădade*	