DISCIPLINE SHEET

1. Program data

1.1 Institution	"Babeș-Bolyai" University
1.2 Faculty	Faculty of Biology and Geology
1.3 Department	Hungarian Department of Biology and Ecology
1.4 Field of studies	Biology
1.5 The cycle of studies	Master, 4 semesters, full-time
1.6 Study program / Qualification	Medical biology (Hungarian) / Expert biologist, biochemist

2. Discipline data

2.1 Name of the discipline	Biological modelling and epidemiology in R and python with GIS elements						
2.2 Owner of course activities			Assoc. prof. dr. László Zoltán				
2.3 Holder of seminar activities			Assoc. prof. dr. László Zoltán				
2.4 Year of study	1	2.5 The semester	3	2.6. The type of assessment	E	2.7 Discipline regime	Ob.

3. Estimated total time (hours per semester of didactic activities)

3.1 Number of hours per week	4	Of which: 3.2 course	2	3.3 seminar / laboratory	2
3.4 Total hours from the education plan	154	Of which: 3.5 course	56	3.6 seminar / laboratory	28
Distribution of the time fund:					hours
Study according to the textbook, course support, bibliography and notes					28
Additional documentation in the library, on specialized electronic platforms and in the field					20
Preparation of seminars/laboratories, assignments, reports, portfolios and essays					14
tutoring					4
EXAMINATION					4
Other activities:					
3.7 Total hours of individual study					70
3.8 Total hours per semester					154
3.9 Number of Credits					6

4. Prerequisites (where applicable)

4.1 of the curriculums	
4.2 skills	

5. Conditions (where applicable)

5.1 Conducting the course	• Logistic support: multimedia projector • Course support for internal use
5.2 Conducting the seminar/laboratory	• Multimedia projector • Modelling and statistical analysis programs (R, QGIS, etc.), computers (desktop/laptop) • Participation in at least 80% of the laboratory work is a condition for participation in the exam

6. The specific skills accumulated

Professional skills	Solving problems through modelling, algorithmizing, etc.; Description of states, systems, processes, phenomena;
Transversal skills	Research skills, creativity; The ability to conceive projects and carry them out; Ability to solve problems;

7. The objectives of the discipline (resulting from the grid of accumulated skills)

7.1 The general objective of the discipline	• At the end of the course, the student should be able to recognize and use mathematical models associated with biological phenomena to create scenarios and formulate epidemiological models
7.2 Specific objectives	• At the end of the course, the student must be able to recognize and use the mathematical models associated with the following types of biological phenomena: the dynamics of subpopulations in an epidemiological context; ordinary differential equation models for modelling the persistence and resilience of biological networks.

8. Contents

8.1 Course	teaching methods	Remarks
1. Introduction to biological networks, types of networks, properties of biological networks.	Exposition, description, explanation, examples, case study discussions	2 hours each
2. The waterfall model. Patterns of biological networks.		
3. Experimental examinations of networks: (i) chain length; ii) the relationship between complexity and stability.		
4. Classification of nodes in biological networks by different criteria.		
5. Stability of biological networks. Preferential connection.		
6. Epidemiological models: SIR models.		
7. SIR models dependent on frequency and density.		
8. Epidemic dynamics and numerical optimization.		
9. Case Study: Bombay Plague.		
10. Reaction-diffusion models. Deterministic and stochastic models. The Monte Carlo method. Markov chains and processes.		
11. The metapopulation aspects of epidemics. The effect of spatial heterogeneity. The Levins model.		
12. Demographic patterns: extinction-colonization cycles. Implicit, explicit and spatially realistic epidemiological models.		
13. Case studies: bird flu (H1N1) and acquired immunodeficiency syndrome (AIDS)		
14. Case Studies: Modelling Ebola, Rabies and Malaria.		

Bibliography

1. **Barabási, A.-L.**Network science. Cambridge University Press, 2016.
2. **Gilpin, ME, Ilkka A.H**. Metapopulation biology: ecology, genetics, and evolution. No. 504.7 MET. 1997.
3. **Amek, N.**et al. Spatial and temporal dynamics of malaria transmission in rural Western Kenya. Parasite Vectors, 5, 86-86, 2012.
4. **Beyer, HL**Epidemiological models of rabies in domestic dogs: dynamics and control (Doctoral dissertation, University of Glasgow), 2010.
5. **Bivand, RS, Pebesma, EJ, & Gómez-Rubio, V**. Applied spatial data analysis with R. Springer, 2008.

6. **Chongsuvivatwong, V**. Analysis of epidemiological data using R and Epicalc. Book Unit, Faculty of Medicine, Prince of Songkla University, 2008.
7. **Ducrot, C. et al.**Modeling BSE trend over time in Europe, a risk assessment perspective. European journal of epidemiology, 25(6), 411-419, 2010.
8. **Huppert, A., Barnea, O., Katriel, G., Yaari, R., Roll, U., & Stone, L.**Modeling and Statistical Analysis of the Spatio-Temporal Patterns of Seasonal Influenza in Israel. PloS one, 7(10), e45107, 2012.
9. **Lekone, PE, & Finkenstädt, BF**Statistical inference in a stochastic epidemic SEIR model with control intervention: Ebola as a case study. Biometrics, 62(4), 1170-1177.
10. **Stevens, MH**A Primer of Ecology with R. Springer, 2006.
11. **Stevenson, MA**The spatio-temporal epidemiology of bovine spongiform encephalopathy and foot-and-mouth disease in Great Britain. Unpublished PhD thesis, Massey University, Palmerston North, New Zealand, 2003.

8.2 Seminar / laboratory	teaching methods	Remarks
1. Introduction to the R language, vectors, matrices, data tables, lists.	Individual practical exercises on the computer	2 hours each
2. Creating your own functions in the R language.		
3. Manipulation of data tables in R. Randomization.		
4. Statistical distributions (negative exponential, negative binomial, Cauchy, Lévy).		
5. Network modelling - the effect of chain lengths.		
6. Network modelling - the effect of the density of relationships.		
7. Solving first-order ordinary differential equations in R.		
8. Simple epidemiological models, SIR models.		
9. Density- and frequency-dependent epidemiological models, dynamic SIR models		
10. Numerical optimization: the "maximum likelihood" principle; Modelling the bubonic plague in Mumbai (1905)		
11. Spatial data types and their characteristics. Spatial autocorrelation and spatial data analysis.		
12. Case studies: the spread of BSE and H1N1		
13. Case Studies: AIDS and Ebola		
14. Case Studies: Rabies and Malaria		

Bibliography

1. **Stevens, MH**A Primer of Ecology with R. Springer Science & Business Media, 2009.
2. **Bivand, RS**, et al. Applied spatial data analysis with R. Vol. 747248717. New York: Springer, 2008.

9. Corroboration of the contents of the discipline with the expectations of representatives of the epistemic community, professional associations and representative employers in the field related to the program

Through the use of computer simulations of various biological phenomena, the objectives achieved during the semester help to deepen the understanding of mathematical tools and their use in solving various ecological problems related to biological networks and epidemics - which in research/on the labour market is in accordance with the requirements current.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 evaluation methods	10.3 Weight of the final grade
10.4 Course	Capacity to use the information in a new context	Written exam	50%

10.5 Seminar/ laboratory	Skills to identify ecological phenomena and corresponding mathematical models. The ability to formulate mathematical models in the R language.	Written exam	50%
	Skills following a laboratory protocol	- it's not necessary	

10.6 Minimum Performance Standard
75% of the courses are compulsory Successful completion of the practical exam is mandatory. The result of the final exam must be at least 5.

Date of completion	Course owner's signature	Signature of the seminar holder
11.07.2024	Assoc. prof. dr. László Zoltán	Assoc. prof. dr. László Zoltán

Date of approval in the department	Signature of the department director
16.07.2024	Assoc. prof. dr. Keresztes Lujza