Final exam topics
Biology MSc
Ecology, Evolution, Conservation Biology specialization
(for students starting MSc in 2022 or later)

Evolutionary biology

1. The origin of life. Chemical evolution. RNA world. Non-enzymatic RNA replication. Surface metabolism. Compartmentalization. Chromosome formation. Evolution of genetic code. **Key terms: Error threshold, Eigen's paradox, stochastic corrector model, chemoton model, fitness landscape, ribozyme, mutation, RNA world.**

2. General characterization of major evolutionary transitions. Grouping of major evolutionary transitions. Presentation of the process of major evolutionary transitions through the evolution of mitochondrion and plastids. The endosymbiont theory. Eukaryogenesis. Origin and appearance of plastids on the tree of life. Mutualisms and symbioses. **Key terms: Fraternal major evolutionary transition, egalitarian major evolutionary transition, filial major evolutionary transition, multilevel selection/group selection, the reversibility of evolution, division of labour, heredity systems, methods of storing/transmitting information.**

3. Human evolution. The evolution of human cooperation. Characteristics of human cooperation. Why are we hyper-cooperative? In the light of experiments, what do we think about the evolutionary background of human hyper-cooperativeness? The origin of language. Alternative theories for the evolution of human language. What is the difference between animal communication and human language? The fundamental difference between adaptive and non-adaptive hypotheses. **Key terms: Cooperation, Public Good Game, ultimatum game, social dilemmas, snowdrift game, grandmother hypothesis, confrontational scavenging/hunting theory of language evolution.**

4. Definition and estimation of fitness. Definition and types of phenotypic plasticity. Benefits, costs, and limits of phenotypic plasticity. Evolution and phenotypic plasticity in creating adaptive phenotypic variation. The role of phenotypic plasticity in evolution. **Key terms: biological evolution, adaptive evolution, parallel/convergent evolution, fitness (absolute/relative), phenotype, phenotypic plasticity, reaction norm, countergradient variation, genetic assimilation, Baldwin-effect.**

5. Definition and types of natural selection. Quantitative genetic approach: components of phenotypic variation and the evolutionary roles of heritability and genetic correlations. The effects of natural selection, genetic drift and gene flow on the allele frequencies and evolution of a population. **Key terms: natural selection (stabilizing, disruptive, directional), environmental/ecological/survival selection, sexual selection (intra- / intersexual), fecundity selection, heritability (broad-sense / narrow-sense, + realized), breeder's equation, indirect selection, correlated evolutionary response, genetic drift, gene flow.**

6. The evolutionarily stable strategy for symmetric matrix games in well-mixed infinitely large asexual populations. The behaviour of the H-D model in the symmetric and asymmetric case. Comparison of results with biological observations. The Bishop-Cannings theorem and its

application in the H-D game. The rock-paper-scissors game and its properties. Biological examples of rock-paper-scissors. Why is it important to introduce the dynamic description of games? **Key terms: Concepts of pure and mixed strategy, and phenotypic polymorphism, frequency-dependent selection, payoff matrix, definition of evolutionarily stable strategy, definition of well-mixed (infinitely large) population, definition of symmetric and asymmetric matrix games, definition of evolutionarily stable strategy pair in asymmetric matrix games.**

Ecology

7. Species richness and the structure of biological communities. Species richness and species composition. Our understanding of the number of species living on Earth. Regional and local species richness. Texture and co-texture of communities. Biological diversity. Spatial patterns of communities. Zones, patches, levels. Pattern analysis. The origin of patterns. The importance of patterns. **Key concepts: biological community, species richness, texture, co-texture, alpha diversity, beta diversity, gamma diversity, spatial pattern, pattern analysis.**

8. The dynamics of communities. Succession. Fine-scale changes. The role of disturbance in community dynamics. Stability of communities. **Key terms: non-directional changes in biological communities, vegetation dynamics, secular succession, biotic succession, disturbance, intermediate disturbance hypothesis, non-equilibrium community, stability of communities, resistance, resilience.**

9. Dynamics of habitats and metapopulations. Effects of the loss and fragmentation of natural habitats. Problems of small populations. Metapopulations and metacommunities. Isolation, fusion. Designing a network of protected areas: main aspects. **Key terms: Population, metapopulation, metacommunity, source and sink populations, fragmentation, isolation, edge effect, ecological corridor, SLOSS dilemma.**

10. The relevance of molecular methods in the field of supraindividual biology. Identification of species and individuals. Methods for screening genetic relatedness (at the species, population and individual level) and biodiversity. Estimation of inbreeding and fitness. Methods that require prior genetic knowledge of the species vs. quick and dirty methods that do not require prior knowledge. Sampling, sample handling, contaminations, sample degradation and misleading results. **Key terms: DNA barcoding, biodiversity, genetic relatedness, inbreeding, heterozygosity, tandem re-peats, SNPs, PCR, qPCR.**

Conservation biology

11. Relationships between nature conservation and conservation biology. Distinctive characteristics of conservation biology. The concept, levels and measurement of biodiversity. Need for, role of and characteristics of ideal biodiversity indicators. **Key terms: nature conservation, conservation biology, biodiversity, genetic diversity, organismal**

diversity, ecological diversity, evenness, compositional indicators, structural indicators, functional indicators.

12. Necessary course of actions for successful in situ conservation. Conservation planning. Ecological considerations in conservation management. Preserving habitats in human-modified landscapes. The role of habitat reconstruction. **Key terms: in situ conservation, equilibrium paradigm, non-equilibrium paradigm, natural disturbance paradigm, reserve selection methods, matrix management, land sparing conservation, land sharing conservation, habitat reconstruction, adaptive conservation management.**

13. Nature conservation in the era of climate change and biological invasion. Drivers and evidence of contemporary climate change. Biological effects of climate change. Climate change induced competitive advantage of invasive species; Tools for assessing future climate impacts on biodiversity. **Key terms: greenhouse effect, carbon sequestration, ocean acidification, sea level rise, range shifts, phenological changes, mismatched species interactions, biological invasion, integrated vulnerability assessment, Anthropocene.**

Ethology and behavioural ecology

14. The four questions of ethology. Proximal and ultimate processes leading to the transformation of behaviours either at the level of individuals or populations. Operation of selection on the behaviour phenotype. Epigenetic landscape. Developmental processes and sensitive phases. **Key terms: ritualization, domestication, urbanization, feralization, intra and inter-specific communication, attachment, development, learning, early learning.**

15. Social behaviour. Describe the factors that favour the emergence and maintenance of prosocial behaviours. Agonistic behaviour, aggression and mechanisms of reducing aggression. Formation of hierarchies. Mechanisms of altruistic behaviours. The behaviour of eusocial insects. Communication in competitive and non-competitive contexts. Channels and function of communication. **Key terms: aggression, hierarchy, dominance, parental care, helper behaviour, cooperation, altruism, eusocial species, reliability of communication**.

16. Outlines of the comparative method in ethology. The application of the method for the study of long-term spatial memory (corvids) and social performance (canids). The four basic mechanisms of learning. Latent learning. Relationship between problem-solving behaviour and intelligence. **Key terms: problem-solving behaviour, genetic predispositions, sign stimulus, learning, Rescola-Wagner model, intelligence, habituation, classical and operant conditioning, causal and instrumental learning, taste avoidance.**

17. Evolutionary/ecological conditions favouring the emergence of individual and social forms of learning. Inventing and scrounging as behavioural strategies. Four basic mechanisms of social learning with specific experimental demonstrations. Capacity for culture in non-human animals. **Key terms: social learning, social facilitation, local and stimulus**

enhancement, emulation, imitation, teaching behaviour, ostensive signals, two-action test, invention, animal culture.

18. Sexual selection: mechanisms and consequences. Determinants of the strength of sexual selection. Benefits provided by males and females. Pre- and postcopulatory mechanisms in intra- and intersexual selection. The evolution of sexual signals and mate choice. Mating systems and parental care. Social vs. genetic systems. Polygyny threshold model. **Key terms: Bateman's principle, Bateman gradient, Fisher's runaway selection, Zahavi's good gene hypothesis, handicap principle, Hamilton-Zuk hypothesis, sensory exploitation hypothesis, monogamy, polygamy, extra pair paternity.**

19. Communication and signalling. Forms, context, function and adaptive value of communication. Coevolution of predators and prey. The evolution of warning colouration, Müllerian and Batesian mimicry. **Key terms: communication, signal, communication contexts, threat, pair recognition, deception and exploitation, social context, aposematism, mimicry, distress signal.**

20. Group life, sociability, territoriality. Advantages and disadvantages associated with group living. Optimality models and game theory. The puzzle of altruism and evolutionary paths to cooperate. **Key terms: advantages, disadvantages, resource, competition, game theory, evolutionarily stable strategy, optimal territory size, multilevel selection, altruism, Hamilton's rule.**

The topics are covered in the following subjects:

1-3: nagyevsb22em Major evolutionary transitions L.
4-5: adevo1sb22em Adaptive evolution L.
6: evojatsb22em Evolutionary game theory L.
7-9: okologsb22em Ecology L.; terembub22em Nature and humankind L.
10: gentecub22em Genetechnology L.
11-13: konzbisb22em Conservation biology L.
14-16: etologsb22em Ethology L.
17: szoctasb22em Social learning L.
18-20: visokosb22em Behavioural ecology L.

Choreography of the final exam

Each student should express his/her knowledge from 2 final exam topics.
1. Major topic. Each student selects a subset of 4 topics from the final exam topics which are close to his/her MSc Thesis work and submits this selection to the final exam committee beforehand. At the start of the exam, the student draws 1 topic from this subset and receives 15 minutes to talk about it.
2. Minor topic. The final exam committee selects 1 topic from the rest of the final exam topics (not included in the student's preferred subset). There will be 10 minutes available to elaborate that topic.