

# Contents

<b>Introduction</b> . . . . .	xiii
Corinne FORTIN and Julie GOBERT	
<b>Part 1. Teaching of Evolution and Beliefs.</b> . . . . .	1
<b>Chapter 1. Student Positions in Learning about Evolution in Relation to Religious Beliefs and Scientific Knowledge</b> . . . . .	3
Hanaa CHALAK, Marco BARROCA-PACCARD and Francis ROUQUET	
1.1. Introduction . . . . .	3
1.2. A look at French school curricula . . . . .	4
1.3. Tensions between scientific knowledge and religious beliefs in the teaching of evolutionary theory . . . . .	6
1.4. The compartmentalization of evolutionary knowledge and religious beliefs . . . . .	7
1.5. A case study carried out in two 10th grade classes . . . . .	9
1.5.1. Study of students' statements exclusively mobilizing scientific elements . . . . .	13
1.5.2. Study of students' statements that mainly mobilize elements related to religion . . . . .	14
1.5.3. Study of students' statements that jointly mobilize scientific and religious elements . . . . .	16
1.6. Discussion of the students' positions. . . . .	18
1.7. Conclusion . . . . .	20
1.8. References . . . . .	20
<b>Chapter 2. Relationships between the Ideas of Randomness and Understanding of the Evolution of Life among French High School Students</b> . . . . .	23
Magali COUPAUD, Julie GOBERT, Jérémy CASTÉRA and Alice DELSERIEYS	
2.1. Introduction . . . . .	23
2.2. Multiple meanings of randomness in common thought and epistemological contributions . . . . .	24

2.3. The UnRESt questionnaire: testing the understanding of randomness and the evolution of life among schoolchildren . . . . .	27
2.3.1. Development of the UnRESt questionnaire. . . . .	27
2.3.2. The UnRESt questionnaire. . . . .	28
2.4. Data analysis methodology . . . . .	31
2.5. Results and discussion. . . . .	32
2.5.1. Students' conceptions of randomness . . . . .	32
2.5.2. Influence of students' conceptions of randomness on their understanding of evolution . . . . .	33
2.5.3. Various conceptions of randomness. . . . .	36
2.5.4. A lack of relationship between "contingency" randomness and the degree of understanding of the evolution of life. . . . .	36
2.5.5. A relationship between "probability" randomness and the degree of understanding of the evolution of life, according to the context of the items . . . . .	37
2.5.6. A relationship between "destiny" randomness and the degree of understanding of the evolution of life . . . . .	38
2.6. Conclusion . . . . .	38
2.7. Appendix . . . . .	39
2.8. References . . . . .	40
<b>Chapter 3. The Theory of Evolution: Possible Tensions between Science and Religious Beliefs . . . . .</b>	<b>45</b>
José Luis WOLFS	
3.1. Introduction . . . . .	45
3.2. Theoretically possible positions between science and religious beliefs. . . . .	46
3.3. Conceptions of the secularization of science among students from 16 countries . . . . .	49
3.4. Some factors that may influence a secularized view of science and students' conceptions of evolutionary theory. . . . .	54
3.4.1. Factors likely to influence a secularized conception of science. . . . .	58
3.4.2. Factors that may influence students' representations (knowledge vs. beliefs) about evolutionary theory . . . . .	60
3.4.3. The effect of views on the secularization of science on the degree of knowledge and agreement with the theory of evolution . . . . .	63
3.4.4. Effect of relationship with the Scriptures on the degree of knowledge of and agreement with the Darwinian theory of evolution . . . . .	64
3.5. Some conclusions and avenues for reflection at the pedagogical and didactic level . . . . .	64
3.6. References . . . . .	68

<b>Part 2. Teaching Evolution: Educational and Training Issues. . . . .</b>	<b>71</b>
<b>Chapter 4. If Nothing Makes Sense without Evolution, What Sense Can Be Made of the Biology Content of the Official French School Curriculum? . . . . .</b>	<b>73</b>
Marco BARROCA-PACCARD	
4.1. Introduction . . . . .	73
4.2. The place of evolutionary theory in the teaching of biology . . . . .	74
4.3. Methodology . . . . .	76
4.4. Analysis of the entire biology school curriculum . . . . .	78
4.5. Analysis of evolutionary and genetic themes (class 2) . . . . .	81
4.5.1. Overall analysis of the evolutionary and genetic themes . . . . .	81
4.5.2. A look back at the evolutionary themes of the “history of life” theme in high school senior year (BO special edition No. 8 of 2019) . . . . .	84
4.6. Discussion and conclusion . . . . .	85
4.7. References . . . . .	86
Academic programs . . . . .	88
<b>Chapter 5. What if the Chimpanzee Belonged to the Genus <i>Homo</i>? Circulation of Knowledge and Curricular Re-Problematization. . . . .</b>	<b>89</b>
Corinne FORTIN	
5.1. Introduction . . . . .	89
5.2. Conceptual framework of curricular re-problematization in the didactic approach . . . . .	90
5.3. The circulation of knowledge relating to the genus <i>Homo</i> . . . . .	92
5.4. Indicators of the scientific problematization of the genus <i>Homo</i> . . . . .	93
5.5. Indicators of curricular re-problematizations of the genus <i>Homo</i> . . . . .	97
5.5.1. Curricula of competitive examinations for the recruitment of teachers . . . . .	98
5.5.2. School curricula . . . . .	101
5.6. Circulation of knowledge and re-problematization of the genus <i>Homo</i> . . . . .	105
5.7. To renew the circulation of knowledge: new ways of thinking about curricular re-problematization . . . . .	108
5.8. Conclusion . . . . .	110
5.9. References . . . . .	111
<b>Chapter 6. The Current “Synthesis versus Extended Theory of Evolution” Controversy: A Training Opportunity about the Nature of Science . . . . .</b>	<b>117</b>
Magali FUCHS-GALLEZOT and Corinne FORTIN	
6.1. Introduction . . . . .	117
6.2. Contemporary controversies: between uncertainties and disagreements . . . . .	118
6.3. Nature of science through contemporary controversies . . . . .	120

6.3.1. Teachers' visions of science and difficulties in teaching NoS . . . . .	120
6.3.2. Characterization of NoS for thinking about training content on science . .	121
6.3.3. Characterization of contemporary scientific controversies . . . . .	124
6.4. Main epistemological issues of the MEST/EEST controversy. . . . .	126
6.5. The MEST/EEST controversy: an opportunity for teacher education? . . . . .	129
6.6. Conclusion . . . . .	134
6.7. References . . . . .	135

**Chapter 7. Historical Controversy over the Ages of the Earth and the Necessity for Deep Time for Darwinian Selection: Its Reception in Teacher Education . . . . .** 139

Patricia CRÉPIN-OBERT

7.1. Context and issues . . . . .	139
7.2. The historical construction of the problem of the age of the Earth via a founding text by Darwin . . . . .	140
7.2.1. A problem federated by a scientific community . . . . .	141
7.2.2. A problem co-constructed between facts and explanations in an evolutionary framework . . . . .	142
7.2.3. A problem trying to be solved by quantitative reasoning . . . . .	144
7.2.4. A problem, object of controversy between historical science and experimental science. . . . .	146
7.3. Epistemological insights and the problematization of the age of the Earth . . .	148
7.3.1. Short time versus long time: a major and recurrent obstacle in the history of science. . . . .	148
7.3.2. From an assertoric knowledge to an apodictic knowledge . . . . .	149
7.3.3. Learning objectives with an epistemological purpose refocused on the construction of a historical problem . . . . .	151
7.4. Problem and research questions . . . . .	154
7.5. Teacher training scenario and data collection . . . . .	155
7.5.1. First training period: emergence and collection of initial representations on the age of the Earth. . . . .	156
7.5.2. Second training period: plurality of methods on the ages of the Earth during three centuries. . . . .	157
7.5.3. Third training period: study of a historical source and collection of teachers' productions . . . . .	157
7.6. Results . . . . .	158
7.6.1. The same heterogeneity in the spontaneous responses of the trainees and the misconceptions of the pupils in 9th grade. . . . .	158
7.6.2. Personal conceptions in the epistemology of science out of step with the activity of a scientist. . . . .	160
7.7. Conclusion and outlook . . . . .	163

7.8. References . . . . .	164
7.8.1. Contemporary references. . . . .	164
7.8.2. Historical sources. . . . .	167
<b>Chapter 8. The “Conceptual Landscape” of Evolution: A Possible Instrument for Training of Earth and Life Sciences Teachers. . . . .</b>	<b>169</b>
Fabienne PAULIN	
8.1. Introduction . . . . .	169
8.2. Evolution: greater visibility of epistemological diversity . . . . .	171
8.2.1. A proposal that persists, gradualism that fades. . . . .	171
8.2.2. Epistemological openness and the diversity of evolutionary problems. . . . .	173
8.3. Construction of conceptual landscapes . . . . .	176
8.3.1. The association network . . . . .	177
8.3.2. Data collection and processing. . . . .	178
8.3.3. Conceptual landscape analysis grid . . . . .	180
8.4. Results . . . . .	182
8.4.1. Association networks and conceptual networks . . . . .	182
8.4.2. The conceptual landscape of researchers . . . . .	183
8.4.3. The conceptual landscape of ELS teachers . . . . .	184
8.4.4. The conceptual landscape of students in the high school senior class . . . . .	186
8.5. Discussion . . . . .	188
8.5.1. Conceptual landscapes: the dominant place of selection and Darwin: the imprint of STE? . . . . .	188
8.5.2. Researchers on the side of “processes” and causes, teachers on the side of “patterns” and effects . . . . .	189
8.5.3. A fragmented conceptual network among teachers, more homogeneous among researchers . . . . .	191
8.6. Conclusion . . . . .	192
8.7. References . . . . .	193
<b>Part 3. Teaching Evolution: Conceptions and Obstacles. . . . .</b>	<b>199</b>
<b>Chapter 9. Building a Reasoned History of the Living World at School: Under What Conditions? . . . . .</b>	<b>201</b>
Denise ORANGE RAVACHOL	
9.1. Introduction . . . . .	201
9.2. The history of the living at the heart of societal concerns . . . . .	202
9.3. Problematizing to think about a reasoned history of the living . . . . .	203
9.4. Safeguards and specificity of reasoning in historical problematization . . . . .	206
9.5. Reconstruction of biological crises. . . . .	208
9.6. The reconstruction of the origin of life. . . . .	212

9.7. Conclusion and didactic perspectives . . . . .	215
9.7.1. To free oneself from explanations in short stories (storytelling) . . . . .	216
9.7.2. Mobilizing safeguards to avoid first-level catastrophism . . . . .	216
9.7.3. Thinking about the contingency that makes an event by coupling the “rewinding/unwinding” of history . . . . .	217
9.8. References . . . . .	218
<b>Chapter 10. The Concept of Species in Thinking about Evolution and the Scientific Classification of Living Things: Comparative Approach at Different School Levels . . . . .</b>	<b>221</b>
Yann LHOSTE	
10.1. Introduction . . . . .	221
10.2. Species as an obstacle to the teaching of biology . . . . .	223
10.2.1. Epistemological approach . . . . .	223
10.2.2. The concept of species: an objective-obstacle? . . . . .	226
10.3. Theoretical and methodological framework . . . . .	226
10.3.1. Modeling teaching and learning situations in terms of structuring contexts . . . . .	226
10.3.2. Problematic and research question . . . . .	227
10.4. First didactic investigation: a case study on evolution in 11th-grade . . . . .	228
10.4.1. The device . . . . .	228
10.4.2. Analysis of an extract from the scientific debate . . . . .	228
10.4.3. Conclusion of this first case study . . . . .	231
10.5. Second didactic investigation: a case study on the classification of life in kindergarten and 1st-grade . . . . .	232
10.5.1. The device . . . . .	232
10.5.2. Didactic analyses . . . . .	232
10.5.3. Conclusion of this second case study . . . . .	238
10.6. Discussion and conclusion . . . . .	238
10.7. Appendix . . . . .	239
10.8. References . . . . .	240
<b>Chapter 11. Conditions for the Construction of the Darwinian Concept of Natural Selection by 6th-Grade Pupils in French-Speaking Belgium . . . . .</b>	<b>243</b>
Jean-François PONCELET, Christian ORANGE and Jean-Christophe DE BISEAU	
11.1. Introduction . . . . .	243
11.1.1. Natural selection . . . . .	244
11.1.2. Epistemological obstacles . . . . .	246
11.1.3. ...to students’ conceptions . . . . .	248
11.1.4. The value of problematization in understanding the learning of natural selection . . . . .	250

11.2. Analysis device and methodology . . . . .	252
11.2.1. Didactic intervention . . . . .	255
11.3. Results. . . . .	260
11.3.1. Individual student explanations at the beginning and end of the sequence . . . . .	260
11.3.2. Dynamics of the construction of the concept of natural selection . . . . .	265
11.4. Conclusion . . . . .	269
11.5. References . . . . .	270
<b>Chapter 12. Obstacles and Challenges in Teaching Probabilistic Population Thinking in Evolutionary Biology – A Case Study . . . . .</b>	<b>273</b>
Julie GOBERT and Laurent THEIS	
12.1. Introduction . . . . .	273
12.2. Epistemological anchoring . . . . .	274
12.2.1. Strict Laplacian determinism is incompatible with the construction of evolutionary explanations . . . . .	274
12.2.2. Use of probabilities in evolutionary concepts. . . . .	276
12.2.3. Probability: the specificities of probabilistic thinking and the approaches used in the mathematics classroom . . . . .	283
12.2.4. Some ideas to consider the difficulties of linking probability with the teaching of evolution in the ELS class . . . . .	285
12.3. Background to data collection and methodology . . . . .	286
12.4. Analysis of teacher and student activity during group discussion . . . . .	289
12.4.1. Students’ initial predictions about the evolution of the moth population ( <i>Biston betularia</i> ) . . . . .	289
12.4.2. Teacher’s aims to bring out the ideas of survival and differential predation . . . . .	292
12.4.3. A presentation of the model from a deterministic perspective. . . . .	294
12.5. Discussion and conclusion. . . . .	296
12.6. References . . . . .	297
Academic programs . . . . .	299
<b>Conclusion . . . . .</b>	<b>301</b>
Corinne FORTIN and Julie GOBERT	
<b>List of Authors . . . . .</b>	<b>303</b>
<b>Index. . . . .</b>	<b>305</b>