Strategies for Teaching Molecular Biology at Grammar School Level: from Theory to Laboratory Practice

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New Perspectives in Science Education

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Curricular Documents in the Czech Republic

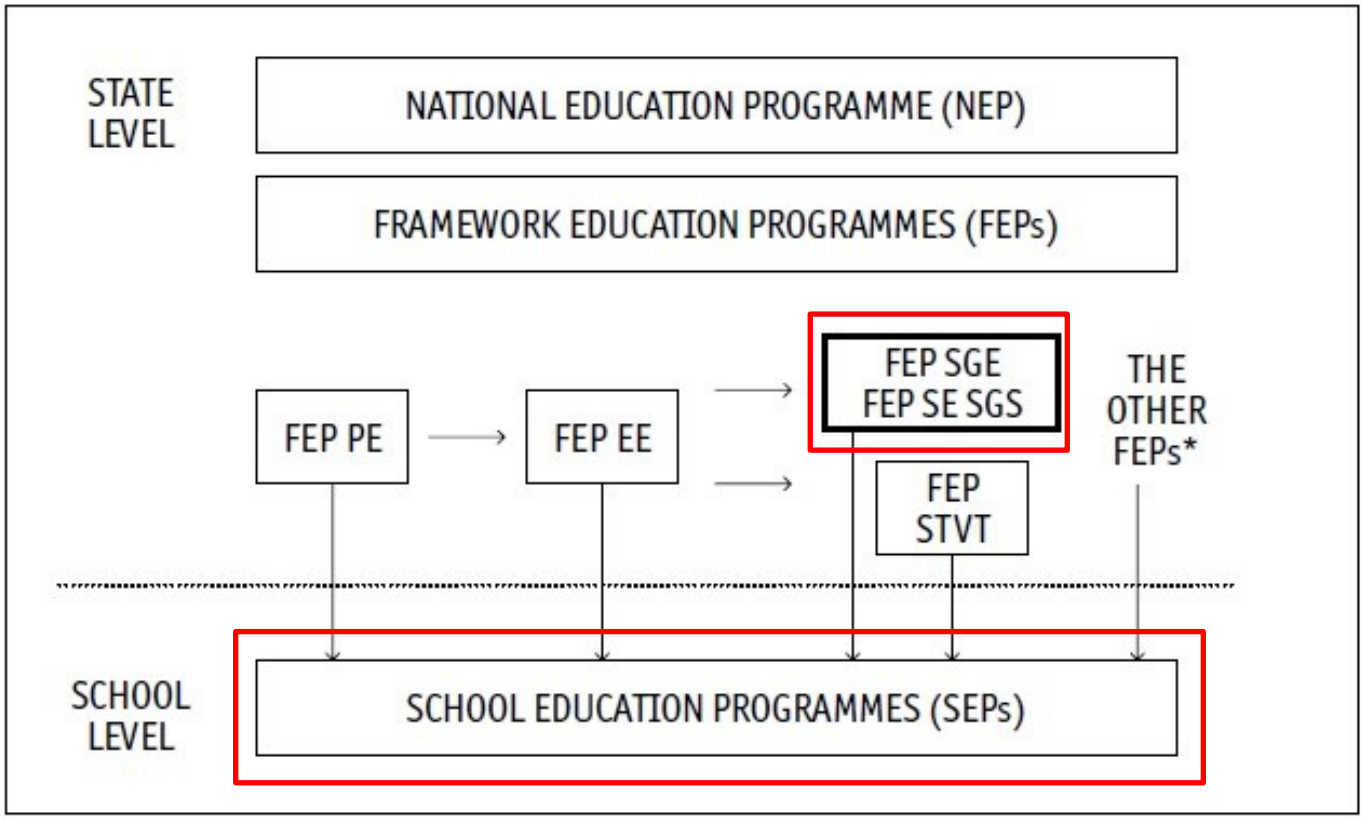


Diagram 1 – The System of Curricular Documents

Legend: FEP PE – Framework Education Programme for Preschool Education; FEP EE – Framework Education Programme for Elementary Education; FEP SGE – Framework Education Programme for Secondary General Education (Grammar Schools); FEP SE SGS – Framework Education Programme for Secondary Education at Sports Grammar Schools; FEP STVT – Framework Education Programme (Programmes) for Secondary Technical and Vocational Training.
* The other FEPs – other framework education programmes which are also delimited by the Education Act and have not been listed above.

Source: Framework Education Programme for Secondary General Education (Grammar Schools), Research Institute of Education in Prague, 2007, p. 5.

Molecular Biology in FEP SGE

GENETICS

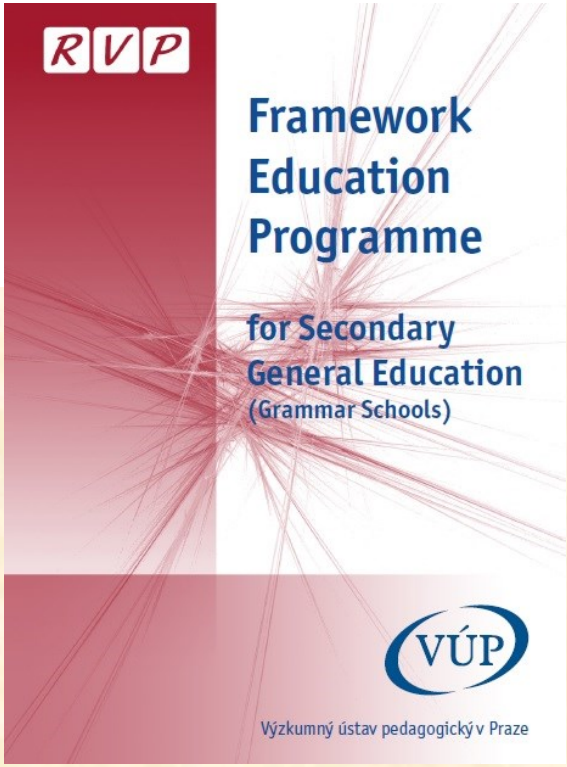
Expected Outcomes

The pupil shall:

- use his/her knowledge of genetic principles to understand the diversity of organisms
- analyse the possibilities of using the knowledge from the field of genetics in everyday life

Subject Matter

- **molecular and cellular fundamentals of heredity**
- **heredity and mutability**
- **human genetics**
- **population genetics**



Source: The educational content of molecular biology in the Framework Education Programme for Secondary General Education (Grammar Schools).

Edition 2007, p. 34.

Molecular biology in SEP – cluster analysis

CLUSTER 1 — 49.1 % of grammar schools (n = 52)

BIOLOGY Grade 9	BIOLOGY Grade 10	BIOLOGY Grade 11	BIOLOGY Grade 12
	BIOLOGY SEMINAR Grade 10	BIOLOGY SEMINAR Grade 11	BIOLOGY SEMINAR Grade 12

CLUSTER 2 — 31.1 % of grammar schools (n = 33)

BIOLOGY Grade 9	BIOLOGY Grade 10	BIOLOGY Grade 11	BIOLOGY Grade 12
	BIOLOGY SEMINAR Grade 10	BIOLOGY SEMINAR Grade 11	BIOLOGY SEMINAR Grade 12

CLUSTER 3 — 19.8 % of grammar schools (n = 21)

BIOLOGY Grade 9	BIOLOGY Grade 10	BIOLOGY Grade 11	BIOLOGY Grade 12
	BIOLOGY SEMINAR Grade 10	BIOLOGY SEMINAR Grade 11	BIOLOGY SEMINAR Grade 12

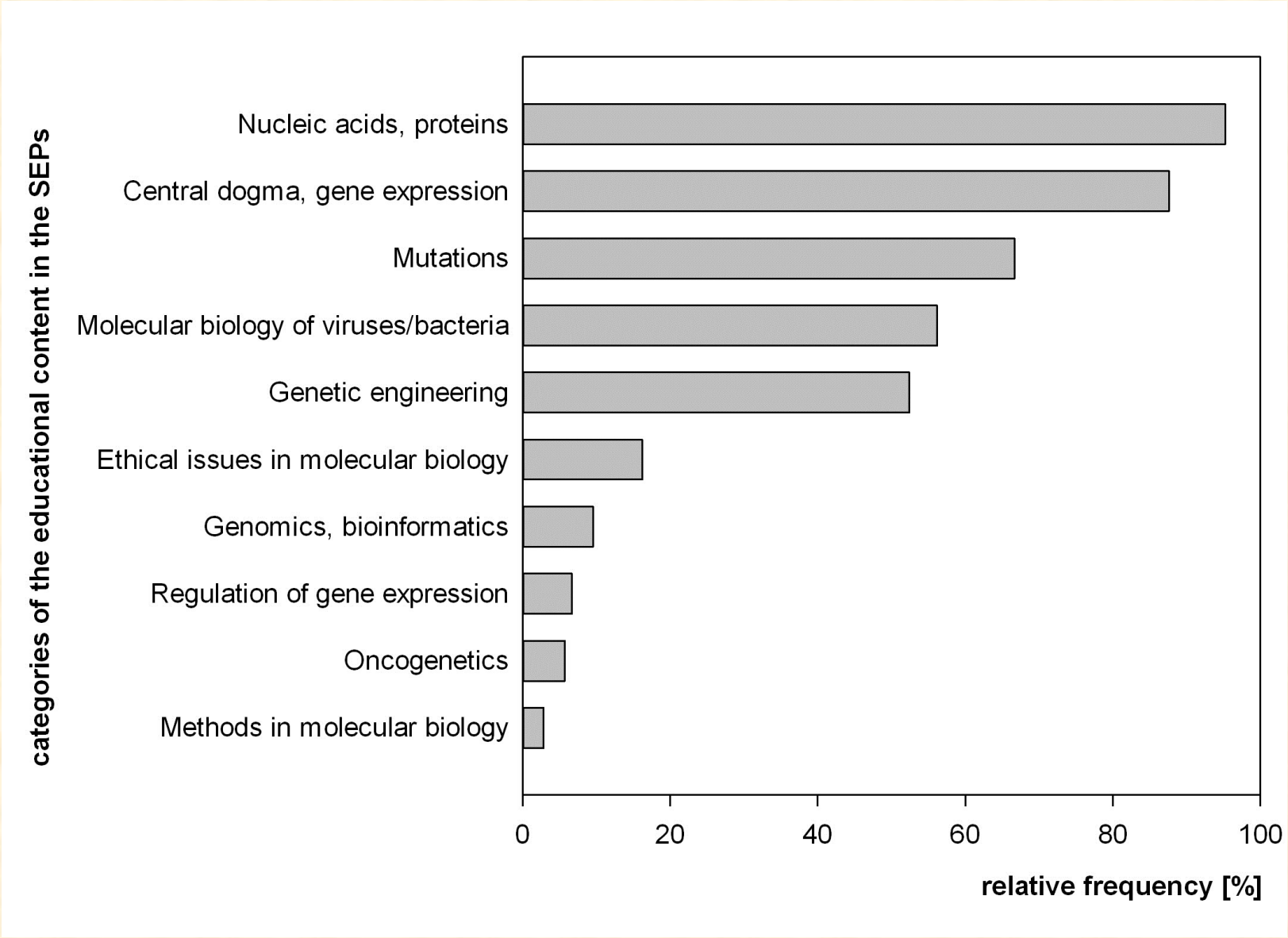
LEGEND

- biology not included in this grade
- molecular biology not included in the educational content
- molecular biology is part of the educational content

Cluster analysis:

- 106 SEPs in analysis (27,8 % of all grammar schools)
- k-means clustering
- subsequent *chi*-square test for independence ($p < 0.0003$)
- 3 clusters of SEPs

Molecular biology in SEP – educational content analysis



Source: Janštová, V., Jáč, M. (2015). Instruction of molecular biology at grammar schools: analysis of the current state and potential of its support. *Scientia in Educatione*, 6 (1), in press (in Czech).

Grammar schools with an optional subject focused on molecular biology

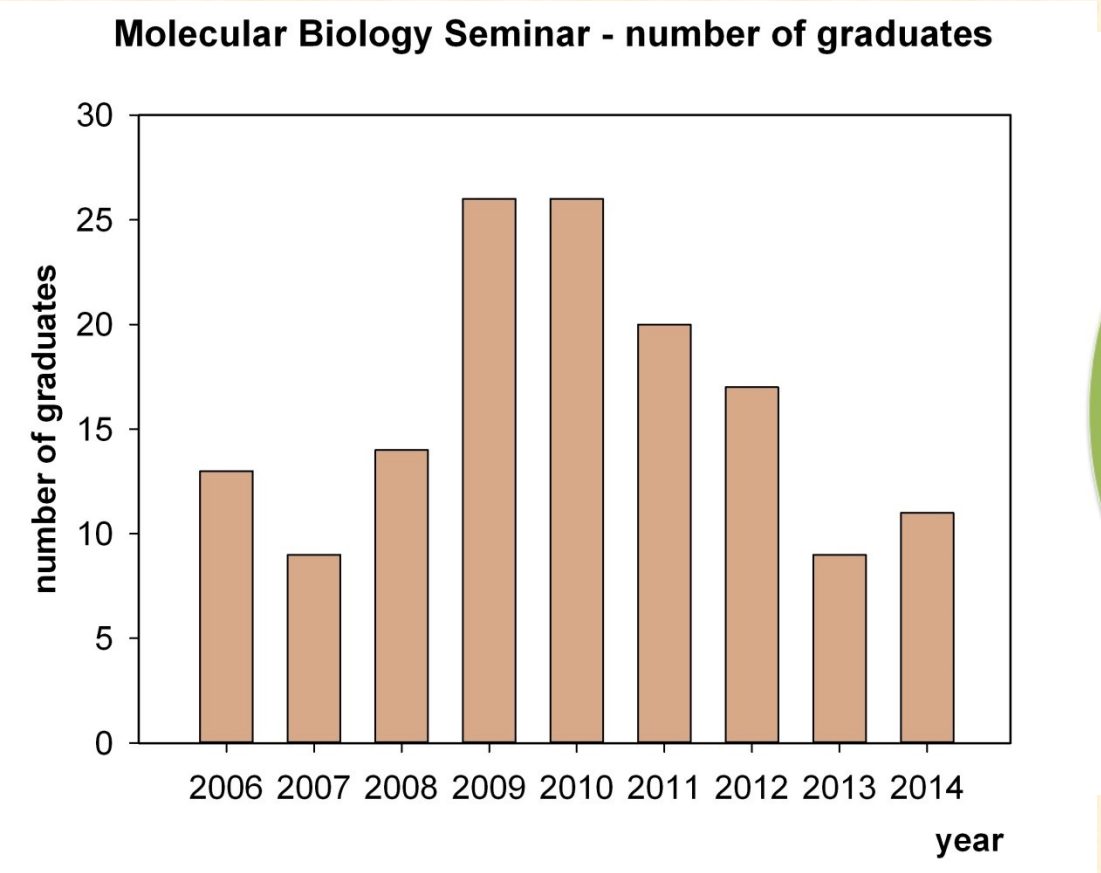
1 : 1 800 000

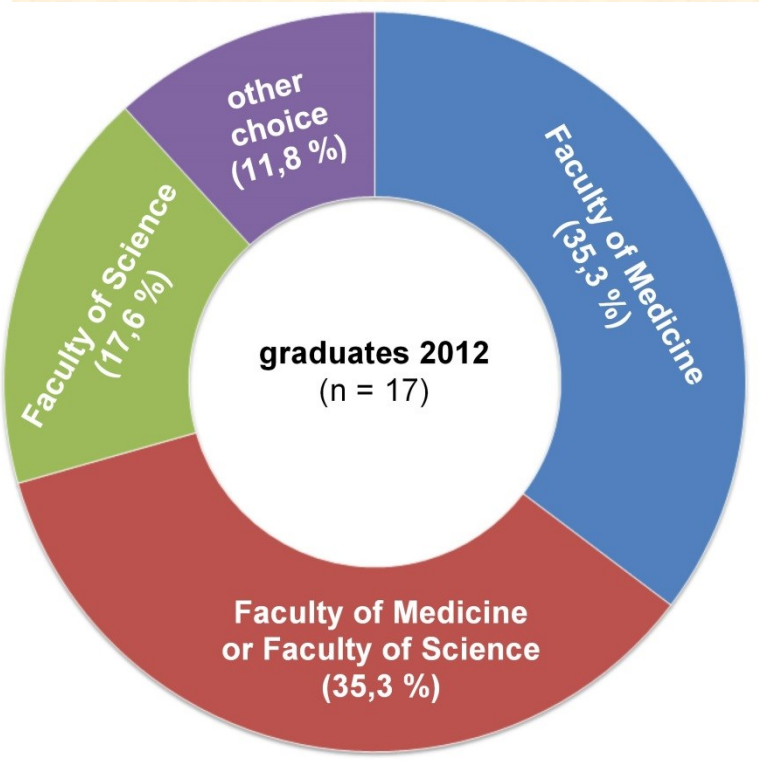
Legend

- Grammar school with an optional subject
- Grammar school with standard curriculum

Molecular Biology Seminar – Palacký Grammar School

- optional subject of instruction, since the school year 2005 – 2006;
- scheduled for grade 12 students with deep interest in biology;
- altogether 145 students successfully participated in this seminar (which is 15.8 % of school graduates during the period 2006 – 2014)





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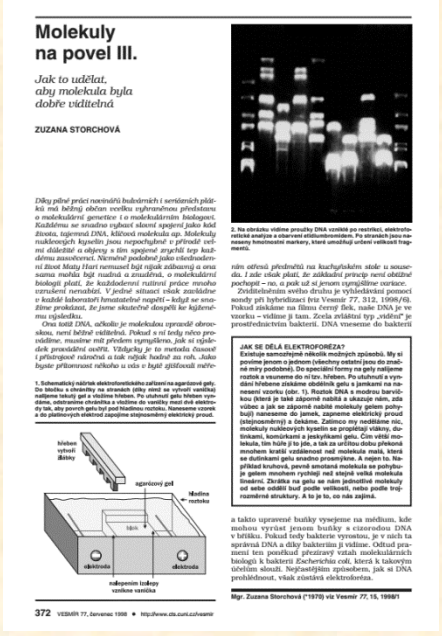
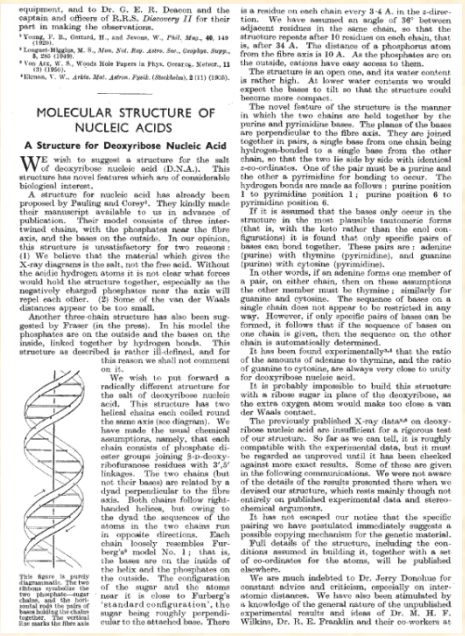
1) „Journal Club“ – critical discussion of non-fiction and scientific papers in the classroom

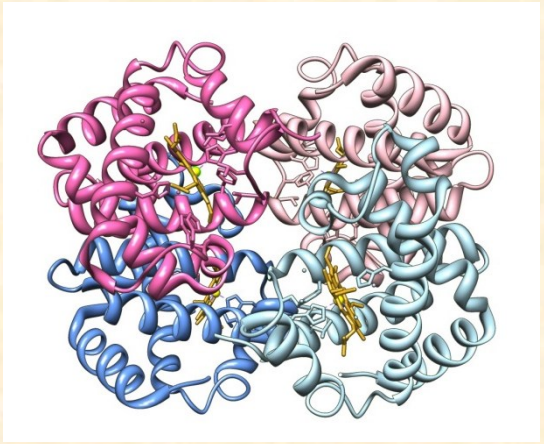


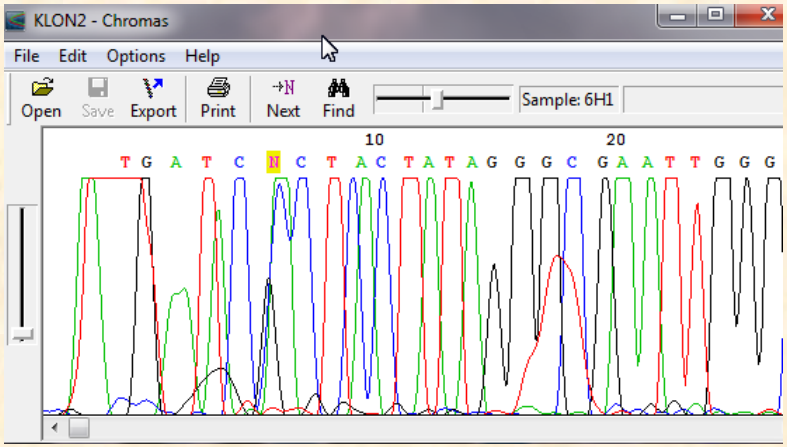


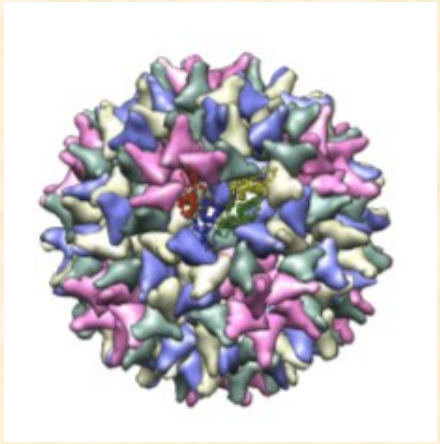
- **an effort to reduce the gap between the educational content of molecular biology in textbooks and the current state of scientific knowledge in the field**
- **we prepared worksheets for students with questions about the content of each paper to facilitate reading and comprehension of the text (and the discussion of the article)**

Strategies for teaching molecular biology at grammar school

2) Bioinformatics tasks – inquiry-based analysis of the biological data







- lessons performed in the computer classroom equipped with interactive whiteboard
- simple bioinformatics tasks included analysis of DNA and protein sequences, computer based 3-D visualization of virus particles and protein structure and construction of phylogenetic trees
- teaching activities were either adopted and modified from educational literature or newly developed

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3) Laboratory exercises: hands-on activities promoting biology inquiries

Simple laboratory exercises:

- DNA extraction from human cheeks cells
- agarose gel electrophoresis using household materials
- observation of mitosis in the onion root tip

Feasibility of advanced laboratory exercises for grammar school students:

a) Laboratory exercise was performed at the grammar school laboratory with equipment from the Mobile Laboratory for Molecular Biology

b) Laboratory exercise was performed as an out-of-school laboratory course at the Faculty of Science, Charles University in Prague

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Three different inquiry-based advanced laboratory exercises were tested:

a) Restriction analysis of bacterial plasmids

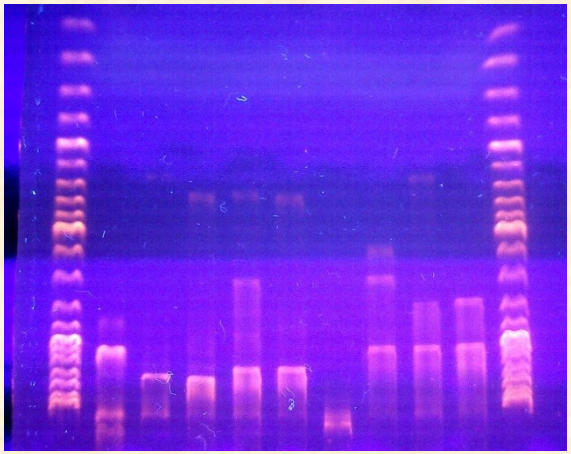
b) SDS-PAGE electrophoresis of proteins

Janštová, V., Pavlasová, L. Černý, J. (2014). Inquiry based practical course focused on proteins. In Rusek, M., Stárková, D. (Eds.), Project-based learning in science education. Prague: Faculty of Education, Charles University in Prague, pp. 40-45.

c) PCR detection of human CCR5 genetic polymorphism

Falteisek, L., Černý, J. & Janštová, V. (2013). Simplified technique to evaluate human CCR5 genetic polymorphism. Am. Biol. Teach. 75 (9), 704–707.

Brief questionnaire survey at the end of each exercise (five-point Likert type scale items, open-ended questions).



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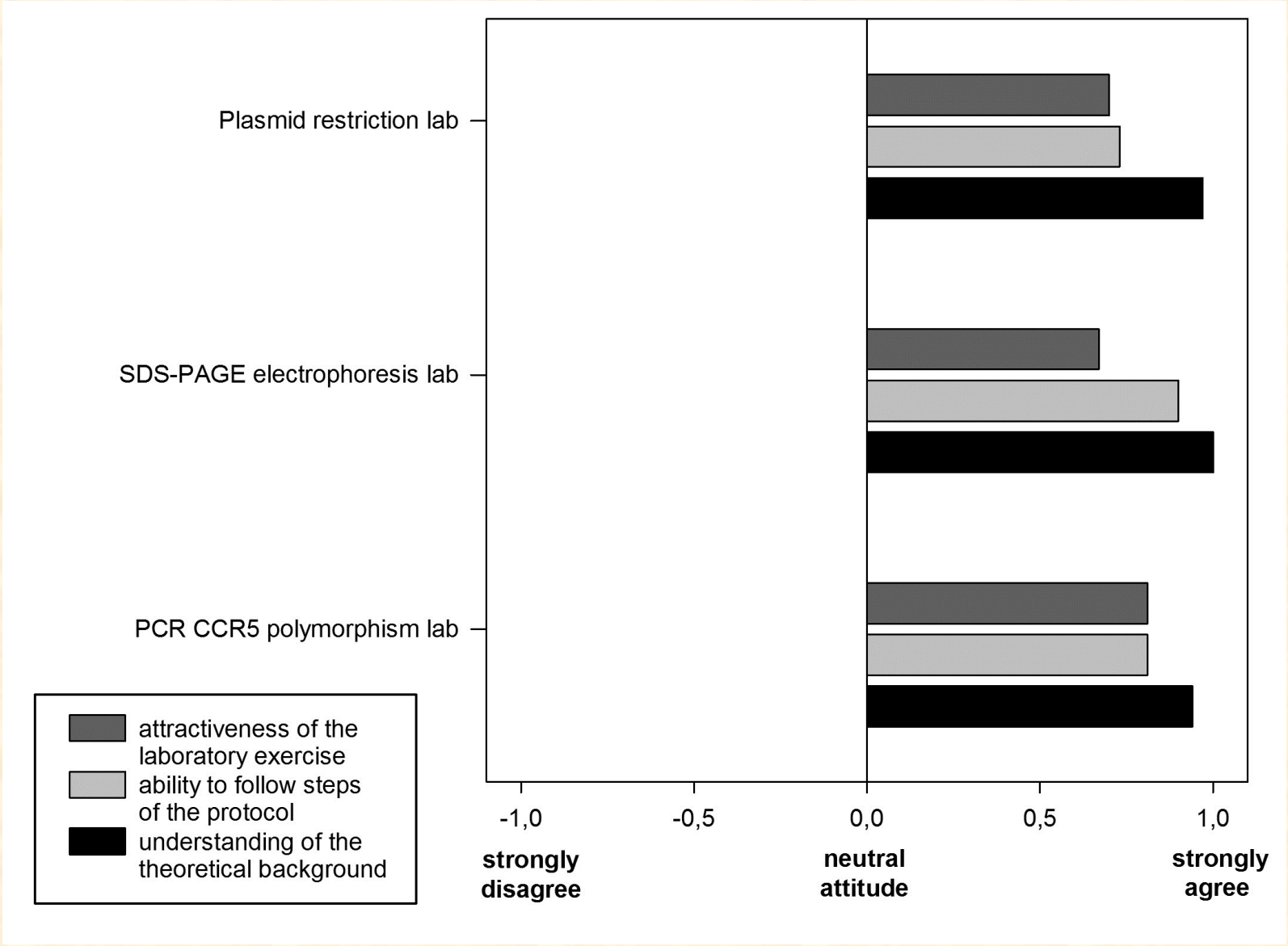

Students' rating of different aspects of three advanced laboratory exercises in molecular biology.
František Palacký Grammar School Valašské Meziříčí, 2011 and 2012, n = 16 students.

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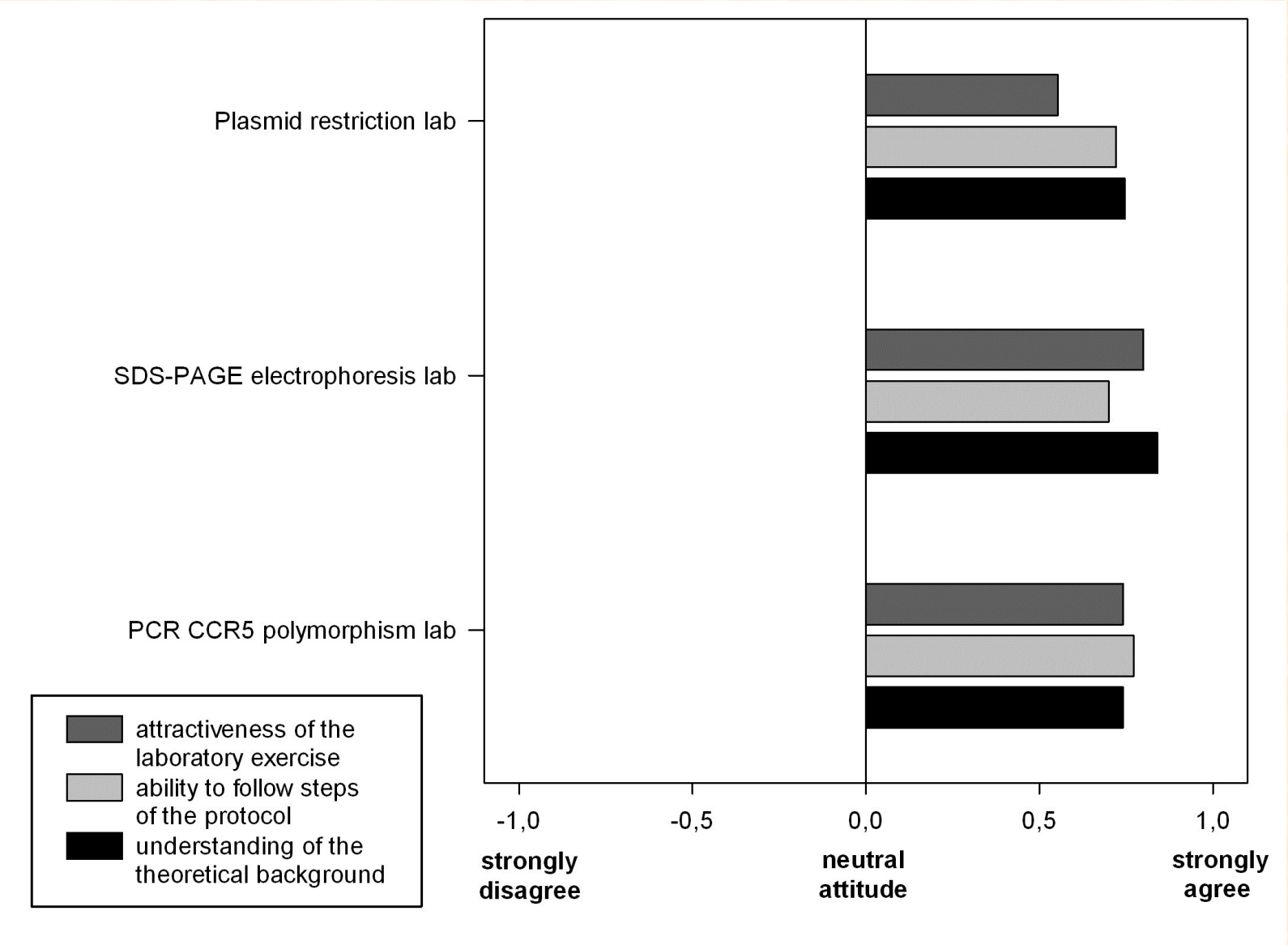

Students' rating of different aspects of three advanced laboratory exercises in molecular biology.

Data collected during the period 2011 - 2013, n = 353 students.

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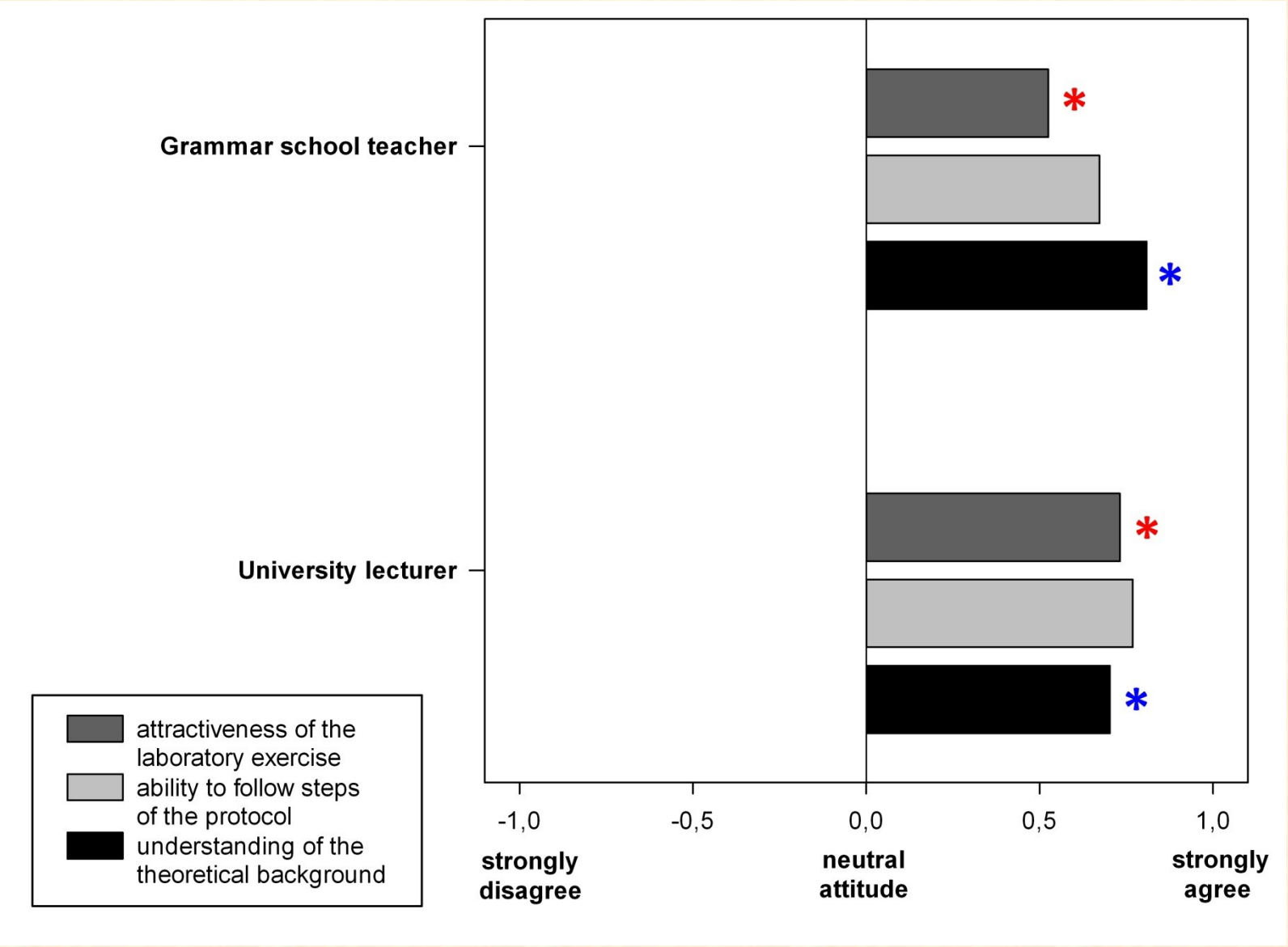

Students' rating of different aspects of three advanced laboratory exercises in molecular biology.
Comparison of the grammar school teacher and the university lecturer.

Thank you for your attention!

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http://www.cetpo.upol.cz/

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