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





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ernational Conference

PERSPECTIVES in SCIENCE EDUCATION



# **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.

<u>Source:</u> 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

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

Edition 2007, p. 34.

### RVP Framework Education Programme for Secondary

General Education (Grammar Schools)



# **Molecular biology in SEP – cluster analysis**

CLUSTER 1		49.1 % of gramm	nar schools (n = 52)	LEGEND	
BIOLOGY Grade 9	BIOLOGY Grade 10	BIOLOGY Grade 11	BIOLOGY Grade 12	biology not included in this grade	
				molecular biology not included in the educational content	
	BIOLOGY SEMINAR Grade 10	BIOLOGY SEMINAR Grade 11	BIOLOGY SEMINAR Grade 12	molecular biology is part	
				of the educational content	
CLUSTER 2	STER 2 31.1 % of grammar schools (n = 33)			Cluster analysis:	
BIOLOGY	BIOLOGY	BIOLOGY	BIOLOGY	<u>Cluster analysis:</u>	
Grade 9	Grade 10	Grade 11	Grade 12	106 SEPs in analysis (27,8 % of	
				all grammar schools)	
	BIOLOGY SEMINAR Grade 10	BIOLOGY SEMINAR Grade 11	BIOLOGY SEMINAR Grade 12	<ul> <li>k-means clustering</li> </ul>	
				<ul> <li>subsequent chi-square test for</li> </ul>	
		10.0% of moment		independence (p < 0.0003)	
CLUSTER 3		19.8 % of gramn	nar schools (n = 21)	3 clusters of SEPs	
BIOLOGY Grade 9	BIOLOGY Grade 10	BIOLOGY Grade 11	BIOLOGY Grade 12		
	BIOLOGY SEMINAR Grade 10	BIOLOGY SEMINAR Grade 11	BIOLOGY SEMINAR Grade 12		

# **Molecular biology in SEP – educational content analysis**



<u>Source:</u> 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



# 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)





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





where the state is the state is

a takto upravené buňky vysejeme na médium, kde mohou vyrůst jenem buňky s cizerodou DNA v břítka, rokud tedy bakterie vynotou, je v nich ta správná DNA a dily bakteriiň ji válime. Odtu dpranemí ten porklud přezíražvý vrdah molekulárních biologů k bakterii Scherichia coli, která k takovým účetími solut. Biejsatějim způsobem, jak si DNA

Mgr. Zuzana Storchová (\*1970) viz Vesmir 77, 15, 1998/1

quipment, and to Dr. G. E. R. Deacon and the aptain and officers of R.R.S. *Discovery II* for their at in making the observations.

<sup>4</sup> Young, P. B., Garnard, H., and Jevons, W., Phil. Mag., 40, 149 (1920).
<sup>8</sup> Longuet-Higgins, M. S., Mon, Not. Ray. Astro. Soc., Graphys. Supp., 5, 285 (1949).
<sup>9</sup> Yon Arr, W. S., Woods Hole Fugers in Phys. Ocear.og. Network, 11 (2) (1949).

The structure is an open one, and its water comis rather high. At lower water contents we we expect the bases to tilt so that the structure of become more compact.

MOLECULAR STRUCTURE OF NUCLEIC ACIDS

A Structure for Deoxyribose Nucleic Ac

W L wish to suggest a structure for the sait of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest.

proposed by Funding and Coreyi. They kindly made P. their matempt variable to us in decases of provided calculations and the second second second provided calculations and the second second second section of the bases on the domitish. In our option, of this structure is unsatisfactory for two remeans to (1) We believe that the material which given the the solid hydrogen atoms it is not clear what forces a magnitude by decaged phosphates mer the scale will 0 distances approach to be to small.

Another three-chain structure has also been sug gested by Praser (in the press). In his model th phosphates are on the outside and the bases on the inside, linked together by hydrogen bonds. Thi structure as described is rather ill-defined, and for this reason we shall not commen



assumptions, namely, that each of easter groups jointy ful-dense. It is reformance resides with Tr2's again not horizon as a start of the start in the bir hand and the start of the handed heises, but vering to either the dynd its sequences of the The start of the sequences of the The sequence of the sequences of the The sequence of the sequences of the the sequences of the sequences of the the bases are not the index of of e the bases are not the index of the sequences of the the bases are not the index of the sequences of the the bases are not the index of the sequences of the the bases are not the index of the sequences of the sequences of the the bases are not the index of the sequences of the

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- 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)

### 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

- 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

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).





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.



Students' rating of different aspects of three advanced laboratory exercises in molecular biology. Data collected during the period 2011 - 2013, n = 353 students.



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



Our friends over in the Czech Republic had some tasty treats while celebrating DNA Day! Thanks to Alzbeta Kantorova sharing this with us!



To se mi líbí · Přidat komentář · Sdílet

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# Thank you for your attention!





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