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INTERACTIVE LEARNING OF MOLECULAR BIOLOGY

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ABSTRACT

This paper brings information about creation and usage of a multimedia guide for practical education of Molecular biology. This guide was designed for students of first year of study at University of Veterinary and Pharmaceutical Sciences Brno.

It includes text describing principle of different molecular methods used in practicals with hypertext links. There are photos and videos documenting equipment, material and different steps of work in practical. It is possible to browse the preview of the photos and to magnify the photo of interest. Videos are streamed for faster loading and better observing. There are also links to interesting web pages, recommended literature, list of terms and abbreviation and control questions. The students can test their knowledge by using control tests. There are simple and difficult variants of test with one or more correct answers, respectively. The tests are created randomly and subsequently evaluated. There is also statistic of obtained results documenting how many points the student received, how long time they needed and how many trials the student used.

This guide satisfies modern trends of education and provides easy and fast access of students to modern information sources.

KEY WORDS

Web page, PCR, photos, videos, tests, statistic

INTRODUCTION

During winter semester 2009 – 2010, methods of molecular biology were for the first time introduced to the practicals of Biology and Genetics in master study programme of both veterinary faculties (Faculty of Veterinary Medicine, Faculty of Veterinary Hygiene and Ecology) University of Veterinary and Pharmaceutical Sciences Brno (VFU Brno). This innovation was financed by the European Social Fund and the State Budget of the Czech Republic with the project "Innovation in Animal Protection and Welfare Education". Our experience with these new practicals was presented in conference (Bártová et al. 2010).

In the practicals, students use the methods of molecular biology (PCR, RFLP, gel electrophoresis) to solve one complex task of bird sex identification from biologic material. The principle of bird sex identification is based on restriction analysis of PCR product of gene CHD (Chromo-Helicase-DNA binding gene). Students form groups of 3-4 students that share set of automatic pipettes, DNA isolation sets, reagents for PCR and RFLP and other material. The sex determination of bird run during three lessons. In the first lesson, students let the bird tissue lyse by enzymes. In the second lesson, they isolate DNA from lysate using column-based DNA isolation sets, prepare mixture for PCR with specific primers and start the DNA amplification in the thermocycler. In the third lesson, they incubate the PCR product with restriction endonuclease *HaeIII* and prepare agarose gel. Subsequently, they load restricted PCR product, controls and DNA molecular weight standard into wells in gel. After electrophoresis, they place the gel into UV light to obtain the result. They identify sex of bird by comparing their sample with controls. One band indicates male sex, two bands indicates female.

It happens that some students do not obtain any result because of mistakes and inaccuracy in critical steps such as DNA isolation, preparation of PCR mixture and sample loading. There is no other change to repeat it, there is not time for it and finally material used for molecular biology is not cheap. That is why the students must have at least basic knowledge about principle and procedure steps of different methods used. For this purpose we prepared textbook "The instructions for practice from biology and genetics" describing methods of molecular biology (Bártová et al, 2010). However, there is a trend not to use only traditional methods of learning and education, but to enhance it with new forms and learning methods, which use electronic technologies, available on the Internet. The efficiency and usefulness of using interactive materials during the education process was verified by Aberson et al (2002) and Law et al (2010). The advantage of multimedia learning is an increased accessibility to information, ease of distribution and ease in updating content compared to printed materials (Chu and Chan, 1998; Ward et al, 2001).

The aim of this paper is to introduce a multimedia guide designed for students of both veterinary faculties VFU Brno for interactive learning of molecular biology.

MATERIALS AND METHODS

Multimedia guide for interactive learning of molecular biology was designed similarly as "Multimedia guide to practical teaching of biology and genetics" (Bártová and Frolková, 2011). Both guides are used by students of VFU Brno for study of Biology and Genetics that is why the similar appearance and structure of guide was used.

We used template of web page free available on Internet and modified it for our purpose. The guide contains text with hypertext links, photos and videos, links to internet sources, recommended literature, list of abbreviation, control questions and control tests.

The text part corresponds to some chapters of handbook "The instructions for practice from biology and genetics" (Bártová et al, 2010). There are theoretical parts describing principle of methods of molecular biology followed with manuals used in practical. The guide contains photos and videos documenting machines, material and procedures from the practical. Photos and videos were made by camera Canon EOS 60D. Photos were consequently adjusted (suitable size, format, basic correction, outlook of miniaturized photos) and incorporated to multimedia guide in form of preview with the possibility of its enlarging. Videos were processed and adjusted (shortened, sheared, converted to suitable format) and incorporated to multimedia guide with the help of streaming (the same style like YouTube). The multimedia guide contains also links to interesting web pages showing animations of biological events and bringing some supplemental information.

Multimedia guide contains control tests that can be used by students to prepare for practicals and test their knowledge. There is a database of questions with correct answers, sorted according to topic. The teacher can create tests with different difficulties (one or more correct answers) and different evaluation of questions (plus points for correct answers, minus points for wrong answers etc.). Tests are generated randomly with subsequent evaluation of the answers. There is a statistic of best results with number of points for tests and with time needed for writing the test.

RESULTS AND DISCUSSION

A multimedia guide for interactive learning of molecular biology was created and placed on <http://opvk2011.ptacisvet.cz/>, where it is accessible without any limitations. The upper menu contains following items: protocols and description of methods, other information, photos and videos, tests and control questions and information about project. Left menu contains detail items of upper menu, e.g. for item DESCRIPTION OF METHODS there are items molecular biology, DNA isolation, PCR, RFLP, Southern blotting, sequencing and genomics. The theoretical part contains text, pictures and hypertext links. You can see example of page describing gel electrophoresis (Fig.1).

Molekulární biologie
VPU Brno, Fakulta veterinární hygieny a ekologie
Ústav biologie a chorob volně žijících zvířat

NÁVODY, POPISY METOD
DAĹŠÍ INFORMACE
FOTO, VIDEO
TESTY, KONTROLNÍ OTÁZKY
O PROJEKTU

Návod do cvičení

- Materiál k vyšetření
- Příprava tkáně k izolaci DNA
- Izolace DNA a PCR
- RFLP, gelová elektroforéza

Popis metod

- Molekulární biologie
- Izolace DNA
- PCR (polymerázová řetězová reakce)
- **Gelová elektroforéza**
- RFLP (restrikční reakce)
- Southern blotting a hybridizace
- Sekvenování
- Genomika, bioinformatika

Gelová elektroforéza

Gelová elektroforéza patří k nejpoužívanějším separačním technikám sloužícím k analýze nukleových kyselin a proteinů.

Princip

Principem metody je **pohyb záporně nabitých molekul DNA** (hlavním nositelem náboje nukleových kyselin jsou záporně nabitá fosfátová skupiny) **v elektrickém poli směrem k anodě**. Pomocí gelové elektroforézy můžeme separovat (oddělovat) molekuly DNA na základě rozdílných rychlostí pohybu molekul DNA v gelu, které jsou nepřímo úměrně **velikosti molekul DNA**.

Elektroforéza se provádí na vhodném nosiči, nejčastěji v **gelu** tvořeném agarózou či polyakrylamidem (ve cvičení bude použita agaróza). Gel je tvořen složitou sítí polymerních molekul s póry, jimiž se molekuly DNA pohybují různou rychlostí v závislosti na velikosti (malé fragmenty se pohybují rychleji, tj. doputují na gelu dále).

Agarózový gel se připravuje v různé hustotě (udávané v % práškové agarózy). Agaróza se rozpouští v pufru, který je také obsažen v elektroforetické vaně jako elektrolyt (ve cvičení bude použit **TBE pufr** obsahující Tris, kyselinu boritou a EDTA).

Vzorky se nanášejí do jamek v gelu, které byly vytvořeny pomocí tzv. hřebíčku. Zatížení DNA (DNA klesne do jamky v gelu) a migrace DNA v gelu jsou zajištěny přidáním tzv. **nanášecího neboli vkládacího pufru**, který je tmavě zbarvený a je tak umožněna kontrola vložení PCR produktu do příslušné jamky a také migrace v gelu.

Pro odhad velikosti pozorovaných DNA fragmentů se do jedné jamky gelu nanáší tzv. **velikostní marker** (hmotnostní standard, DNA ladder = žebřík) o definované velikosti jednotlivých fragmentů (např. 100 bp ladder – viz obr.).

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Fig. 1: Example of page describing gel electrophoresis

The item OTHER INFORMATIONS contains list of terms and abbreviations, recommended literature and links to interested web pages. The item PHOTOS AND VIDEOS contains photos and videos of machines and material used in practical and photos and videos of students during work in practicals. Example of page with photos of machine and material used for gel electrophoresis is seen in Fig. 2. There are small preview of photos that can be enlarged. Videos show students preparing sample, loading DNA in gel etc. There is example of page with video showing DNA loading in gel (Fig. 3). Videos are streamed for better loading and observations.

The item TESTS contains control questions and tests with different difficulty (one or more correct answers) (Fig. 4). The tests are generated randomly from database of questions and subsequently evaluated. If the student registers (write his/her name) before completing test, he/she can observe how successful he/she was. There is a statistic sorting results of test according the number points obtained and time needed for completing the test (Fig. 5). The statistic also evaluates the best result from several trials of one student, so he/she can see if he/she is improving. It is a good motivation for students to be better.

We can evaluate the results of students from the last year. The results of simple test (one correct answer) are summarized in Tab. 1. The best result (6 points) was obtained by 41% of students (n=104), it was simultaneously

the majority of the students. The students tried to solve the test one time, but some of them also 18 times with an average 2 times (median 1 times). The students needed different time to fulfill the test ranging from 4 sec to 131 sec. with an average 93 sec. (median 67 sec.). The results of difficult test (more correct answers) are summarized in Tab. 2. The best result (20 points) was obtained by 11% of students (n=66). Majority of the students (32%) obtained 16 points. The students tried to solve the test one time, but some of them also 18 times with an average 3 times (median 2 times). The students needed different time to fulfill the test ranging from 32 sec. to 481 sec. with an average 136 sec. (median 101 sec.).

Number of points	6	5	4	3	2	1	0	-1	-2	-4	-6
Number of students	43	2	14	2	9	1	18	4	8	2	1
Successful result (%)	41	2	13	2	9	1	17	4	8	2	1

Tab. 1: The result of simple test (one correct answer) – max. 6 points

Number of points	Number of students	Successful result (%)
20	7	11
17	2	3
16	21	32
13	2	3
12	7	11
10	1	1.5
9	1	1.5
8	6	9.1
5	1	1.5
4	7	11
1	1	1.5
0	4	6.1
-1	2	3
-3	1	1.5
-4	1	1.5
-12	1	1.5
-16	1	1.5

Tab. 2: The result of difficult test (more correct answers) – max. 20 points

Interactive materials are useful during the education process (Aberson et al 2002; Law et al 2010). From the results of tests and also from reaction

of the students we can evaluate our guide as a useful, too. The advantage of multimedia learning is ease in updating content compared to printed materials (Chu and Chan, 1998; Ward et al, 2001). Our guide also satisfy this request for multimedia learning, it is easy to correct text, add new photos and new questions in databases, generate new test, control statistic etc.

On the Internet, it is possible to find different web pages with e-learning materials used for study of biology or genetics at Universities, e.g. "Genomics in Medicine" created by Institute of Biology and Department of Medical Genetics 1st Faculty of Medicine, Charles University, Prague and General Teaching Hospital (http://biol.lf1.cuni.cz/extensions/Genomika_v_Medicine/default.html) or "Virtual word of genetics" at the page of Mendel University in Brno (<http://user.mendelu.cz/urban/vsg3/>). The education materials on their web pages contain text, video, source of literature, links to interesting pages, and also audio lectures. Compared to above mentioned web pages, our guide contains also photos, list of terms and abbreviations and especially tests that are used by students for self-evaluation and by teacher for control of students' knowledge.

Fig. 2: Example of page with photos of machine and material used for gel electrophoresis



Fig. 3: Example of page with streamed video

NÁVODY, POPISY METOD	DALŠÍ INFORMACE	FOTO, VIDEO	TESTY, KONTROLNÍ OTÁZKY	O PROJEKTU
Kontrolní otázky <ul style="list-style-type: none"> Co musím znát 	<h2>Zkušební testy</h2> <p>Zde máte možnost otestovat si své znalosti a ověřit si tak, jestli jste porozuměli dané problematice.</p> <p>Máte možnost vybrat si z více variant. Otázky v testu se generují v náhodném pořadí.</p> <p>Řešení zadaného testu</p> <p>Způsob vyhodnocení testu:</p> <ul style="list-style-type: none"> správná odpověď = 1 bodů neodpovězeno = 0 bodů špatná odpověď = -1 bodů <p>jméno: <input type="text"/></p> <p><i>Pokud chcete zařadit výsledek testu do seznamu nejlepších výsledků, zadejte své jméno.</i></p> <p>1) Z jakého vzorku lze izolovat DNA?</p> <ul style="list-style-type: none"> <input type="radio"/> priony <input type="radio"/> savčí erytrocyt <input type="radio"/> ptačí erytrocyt <p>2) Jaké je správné pořadí fází jednoho cyklu PCR?</p> <ul style="list-style-type: none"> <input type="radio"/> denaturace-elongace-terminace <input type="radio"/> iniciace-elongace-terminace <input type="radio"/> denaturace-annealing-extension <input type="radio"/> annealing-extension-terminace 			<p>evropský sociální fond v ČR</p> <p>EVROPSKÁ UNIE</p> <p>MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY</p> <p>OP Vzdělávání pro konkurenceschopnost</p> <p>INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ</p> <p>OPVK</p> <p>Veterinární a farmaceutická univerzita Brno</p>

Fig. 4: Example of page with control tests

NÁVODY, POPISY METOD	DALŠÍ INFORMACE	FOTO, VIDEO	TESTY, KONTROLNÍ OTÁZKY	O PROJEKTU
Nejlepší výsledky				
<p>1. Lehká varianta, 1 správná odpověď, 6 otázek (max 6 bodů)</p> <ol style="list-style-type: none"> 1. as, dosaženo 6 bodů 00:00 minut {0./1x} 2. Tomáš Gála, dosaženo 6 bodů 00:12 minut {0./1x} 3. Michaela Bradáčová, dosaženo 6 bodů 00:13 minut {0./1x} 4. Marie Horáková, dosaženo 6 bodů 00:13 minut {0./14x} 5. Lucie Daňková, dosaženo 6 bodů 00:14 minut {0./1x} 6. Ivana Kozáková, dosaženo 6 bodů 00:14 minut {0./18x} 7. Martina Fuksová, dosaženo 6 bodů 00:15 minut {0./6x} 8. Klára Kijová, dosaženo 6 bodů 00:15 minut {0./13x} 9. Monika Zemanová, dosaženo 6 bodů 00:16 minut {0./5x} 10. Karolína Bendová, dosaženo 6 bodů 00:16 minut {0./5x} 11. Kloubcová, dosaženo 6 bodů 00:17 minut {0./1x} 12. H11128, dosaženo 6 bodů 00:18 minut {0./1x} 13. Uncas, dosaženo 6 bodů 00:19 minut {0./2x} 14. Veronika Mušálková, dosaženo 6 bodů 00:22 minut {0./3x} 15. terina, dosaženo 6 bodů 00:23 minut {0./2x} 16. slaniková, dosaženo 6 bodů 00:25 minut {0./1x} 17. Aneta Novotná, dosaženo 6 bodů 00:27 minut {0./1x} 18. Korábová, dosaženo 6 bodů 00:28 minut {0./5x} 19. H11282, dosaženo 6 bodů 00:32 minut {0./1x} 20. Paulína Adameová, dosaženo 6 bodů 00:32 minut {0./2x} <p>2. Těžší varianta, více správných odpovědí, 10 otázek (max 20 bodů)</p>				
<ul style="list-style-type: none"> Kontrolní otázky Co musím znát Testy Zkušební testy Nejlepší výsledky 				<p>evropský sociální fond v ČR</p> <p>EVROPSKÁ UNIE</p> <p>MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY</p> <p>OP Vzdělávání pro konkurenceschopnost</p> <p>INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ</p> <p>OPVK</p> <p>Veterinární a farmaceutická univerzita Brno</p> <p>Palackého 1/3, 612 42 Brno</p>
zobrazit více				

Fig. 5: Page with the list of best results from test

CONCLUSION

This paper brings information about creation of a multimedia guide for interactive learning of molecular biology. This guide includes education materials with hypertext links, photos and videos, links to internet sources, recommended literature, list of terms and abbreviation, control questions and control tests.

The students can use this guide to prepare themselves theoretically for practical courses, to test their knowledge by help of control tests and to observe photos and videos from practical courses in case they were absent or want to see them again. This guide is placed on internet (<http://opvk2011.ptacisvet.cz/>), so it is easily accessible without any limitations. This guide follows the long-term plan of VFU Brno focused on the modernization of education system, creation of electronic learning texts and easy access of students to modern information resources. In future, english version of this guide will be prepared to be used by students in english form of study.

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