Improving Student Achievement in an Introductory Biology Course with Targeted Multimedia Modules

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Targeted Multimedia Modules (TMMs)

•While Myfanwy is very cute, she would be even more awesome if she were to glow green at night.

•She could then double as a night-light for small children and help them sleep.

•How can we do this????

•Myfanwy is a designer dog. She is a cross between a Bichon and a King Charles Cavalier. Due to the properties of her parents she is hypoallergenic – an example of humans breeding dogs to bring out their desirable traits.

•However, nowadays we can do a whole lot more than just selective breeding.
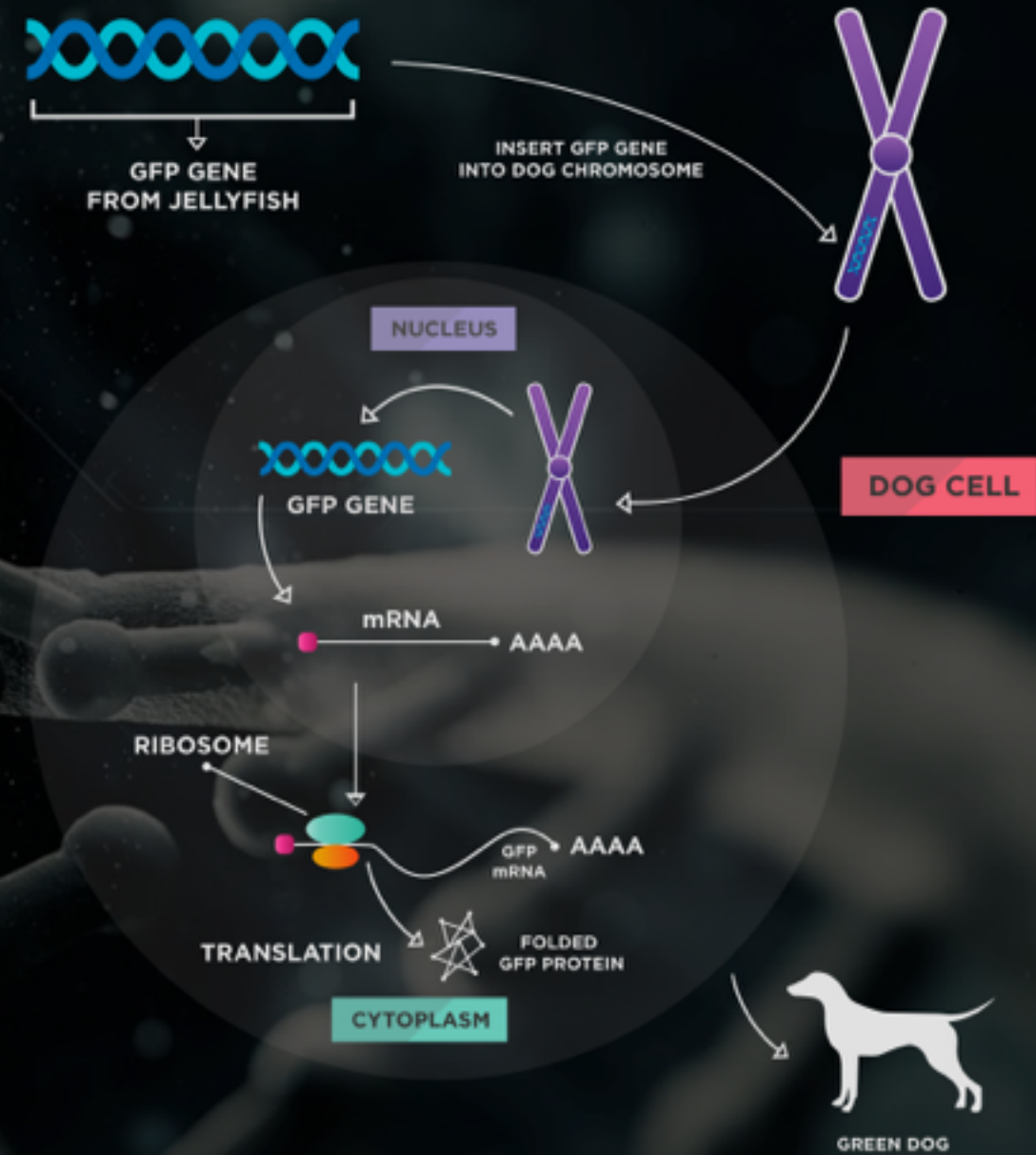
Scroll down to see more...

Next

Biotechnology - How to make your dog glow green

Evil Plan

•To make Myfanwy glow green, like a jelly-fish, we just need to get the GFP DNA sequence into her genome. Then her cells will convert the DNA sequence to mRNA, which will then produce exactly the same protein as in a jelly-fish cell.

•This means that Myfanwy's cells will glow green, just like a jelly-fish!

GFP GENE FROM JELLYFISH

INSERT GFP GENE INTO DOG CHROMOSOME

DOG CELL

NUCLEUS

GFP GENE

mRNA ——> AAAA

RIBOSOME

GFP mRNA AAAA

TRANSLATION FOLDED GFP PROTEIN

CYTOPLASM

GREEN DOG

Prev

Next

Step 1 - capture a glowing Jelly-fish

First you need to capture a Jelly-fish that bioluminesces.
Careful - they can sting!

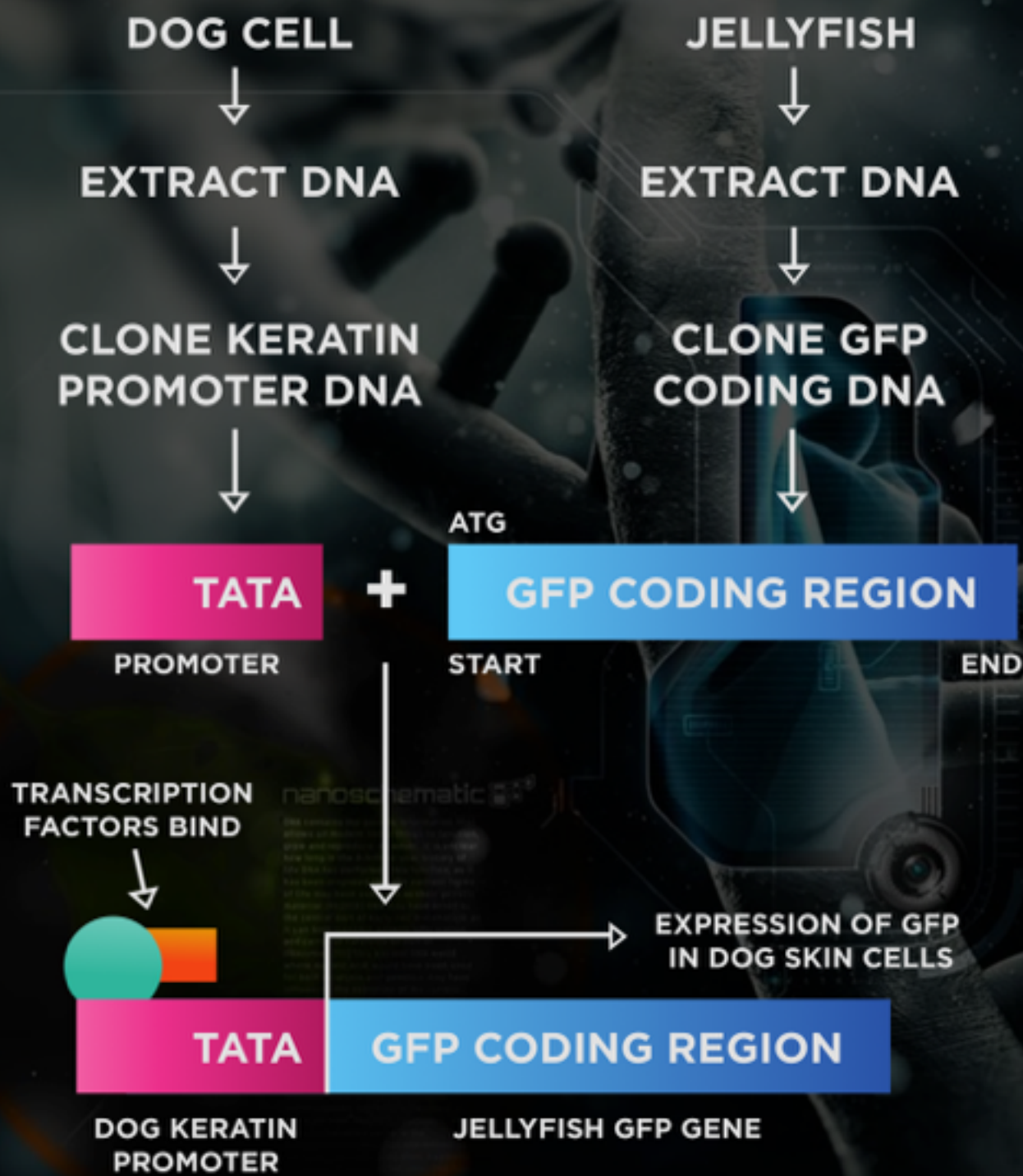Michele Westmorland via Getty Images

Choosing a promoter

DOG CELL
↓
EXTRACT DNA
↓
CLONE KERATIN PROMOTER DNA
↓

JELLYFISH
↓
EXTRACT DNA
↓
CLONE GFP CODING DNA
↓

• So we have to select a dog gene promoter. Different gene promoters will drive expression in different dog cell types.

• As we want Myfanwy to glow in the dark we really want the GFP to be expressed in her skin cells so that it can be seen.

TATA + **ATG** **GFP CODING REGION**

PROMOTER   START   END

TRANSCRIPTION FACTORS BIND

EXPRESSION OF GFP IN DOG SKIN CELLS

TATA **GFP CODING REGION**

DOG KERATIN PROMOTER   JELLYFISH GFP GENE

Promoters

•Gene promoter sequences are very important. All cells in an organisms contain exactly the same DNA sequences, but the cells have very different structures and properties.

•This is because they express different genes from each other, and the promoter sequences control and facilitate this.

•We could engineer Myfanwy to glow green in specific cell types, if we wanted.

•For example we could use a bone-specific promoter to make her bones glow.

•Or a retina-specific promoter to make her eyes glow...

•Or a nasal-epithelial specific promoter to make her nose glow etc.

Lesson Check: question 2

Why do you think it is advantageous for HPV to have the ability to disable tumor suppressor genes in a host cell?

- ○ to be able to generate a tumor
- ● to infect a normal cell and evade the immune system **Incorrect!**
- ○ to generate more cells that HPV can infect
- ○ to cause warts

A virus needs host cells so that the host cellular machinery can make copies of the virus, and thus replicate the virus. When HPV causes cells to lose cell cycle control, they can't shut down, and continue to divide and divide. This creates more host cells for HPV to infect and continue the cycle.
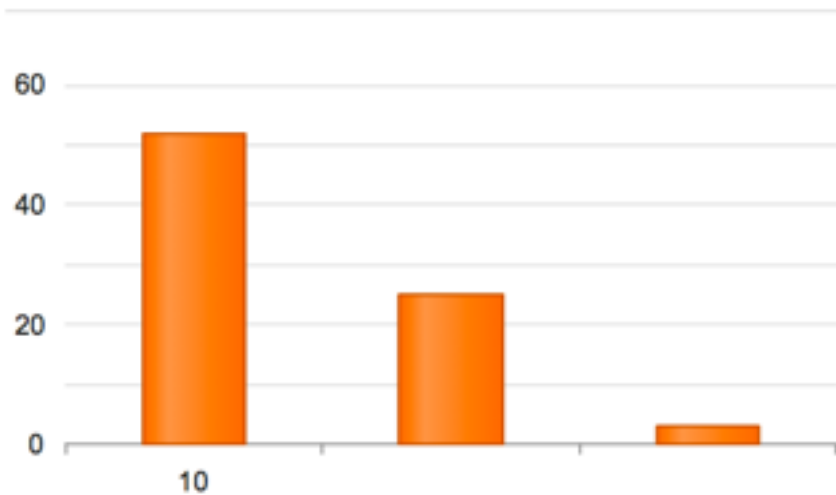
How to make your dog glow green

Play Module

of Students Completing By Day

| | 7/22 | 7/23 | 7/24 |
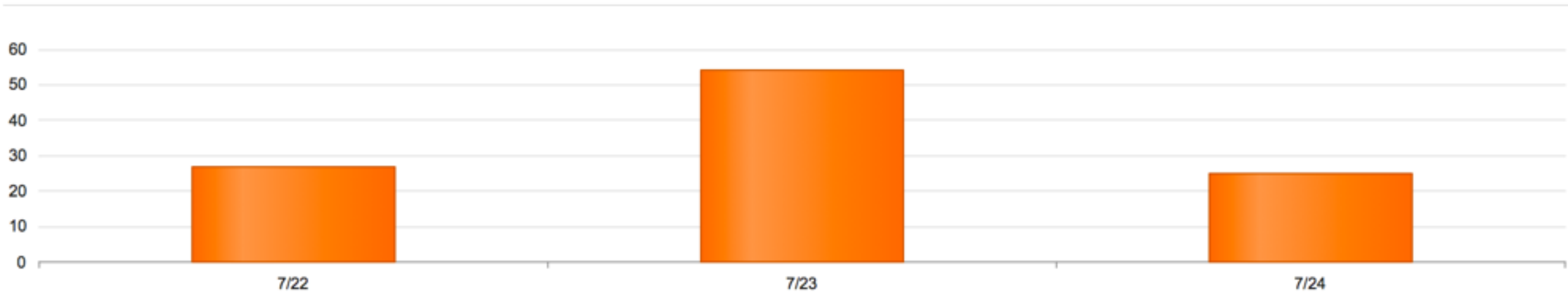
Time Spent

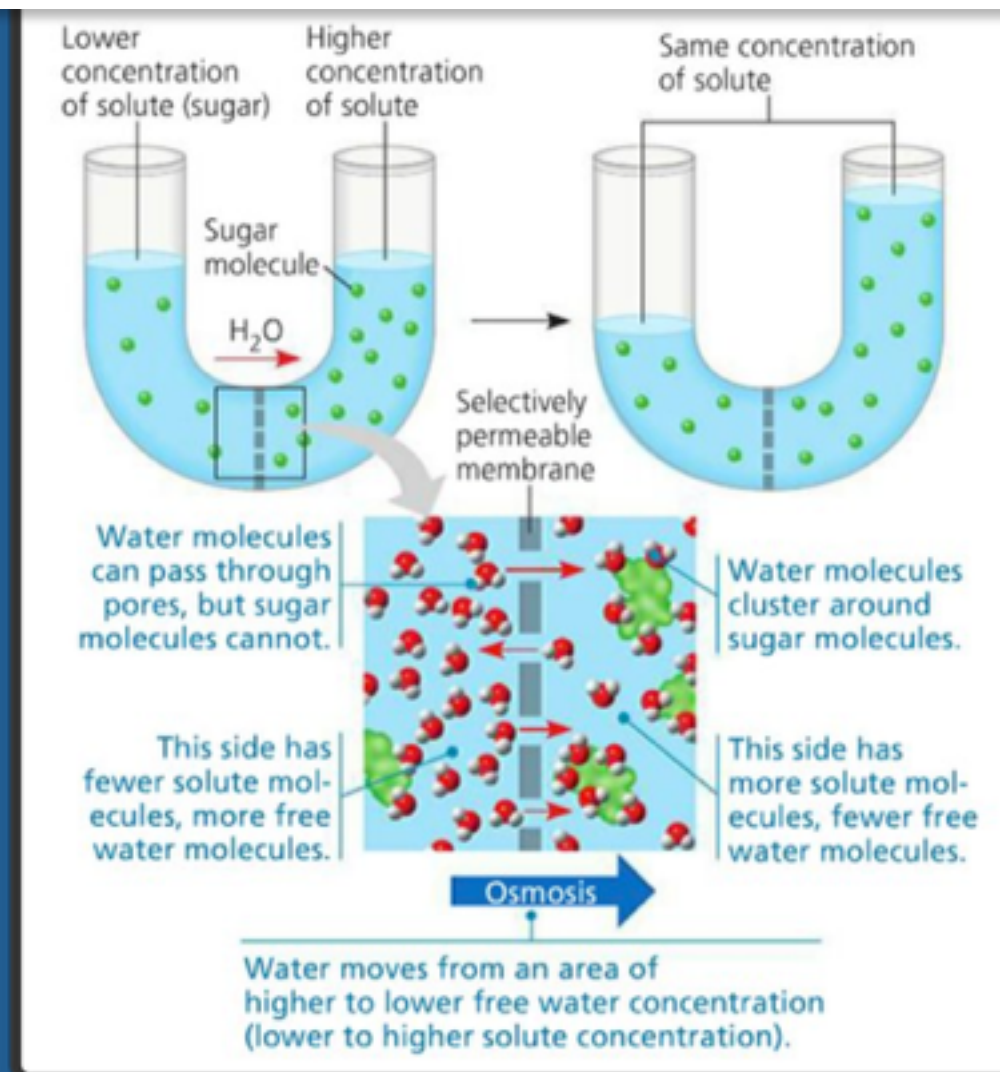## Assessment Score

7 | Minutes on average students took to complete.

••• | 1st Try Assessment Score Average

Questions and Answers   Download Report

If an orange dye capable of passing through the membrane was added to the left side of the tube above, how would it be distributed at the end of the experiment? Would the final solution levels in the tube be affected?

○ The orange dye would move to the right side, final solution levels would rise on the right.

○ The dye can pass through the membrane and would equalize on both sides without changing final solution levels.

○ Water molecules would move to the left side to equalize the amount of dye.

TMM Topics	
Section 1 n=86	Section 2 n=95
Basic chemistry (*Avagadro's number, Acids and Bases & pH and buffers*)	Basic chemistry (*Avagadro's number, Acids and Bases & pH and buffers*)
Mendelian inheritance (*Punnit Possibilities*)	Epigenetics (*Genomic Imprinting*)
Biotechnology (*How to Make Your Dog Glow Green*)	Genetics (*Fly Genetics Recombination*)
Transcription and translation (*Directionality of DNA*)	Genetics (*Fly Genetics Sex-Linked Traits*)
RRMs	
Section 1	Section 2
The structure of proteins (*Proteins Readings*)	The structure of lipids (*Lipids Readings*)
Cell structure (*Cytoskeletal Networks Readings*)	Membrane proteins (*Membrane Transport Readings*)
RRM vs TMM	
Section 1	Section 2
RRM cell cycle regulation (*Cell Cycle Readings*)	TMM cell cycle regulation (*Cancer & Viruses*)
TMM oxidation and reduction (*Energetics*)	RRM oxidation & reduction (*Energetics Readings*)

When both sections received the same TMMs

SAT Math scores were a significant independent predictor of student performance for test questions specific to TMM content (Avagadro's number, Acids and Bases & pH and buffers; β= 0.46, p < 0.001).

No significant effect was observed for SAT Reading or Writing scores.

Furthermore, there was no significant performance difference between morning (M= 81, SD = 0.14) and afternoon sections (M = 83, SD = 0.17) that received the same TMMs, t(175) = -1.0, p = 0.32.

TMM Topics	
Section 1	Section 2
Basic chemistry (*Avagadro's number, Acids and Bases & pH and buffers*)	Basic chemistry (*Avagadro's number, Acids and Bases & pH and buffers*)
Mendelian inheritance (*Punnit Possibilities*)	Epigenetics (*Genomic Imprinting*)
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RRMs

Section 1	Section 2
The structure of proteins (*Proteins Readings*)	The structure of lipids (*Lipids Readings*)
Cell structure (*Cytoskeletal Networks Readings*)	Membrane proteins (*Membrane Transport Readings*)

RRM vs TMM

Section 1	Section 2
RRM cell cycle regulation (*Cell Cycle Readings*)	TMM cell cycle regulation (*Cancer & Viruses*)
TMM oxidation and reduction (*Energetics*)	RRM oxidation & reduction (*Energetics Readings*)

3.3 Analysis 3: Performance of students that completed TMMs compared to those that did not.

Table 1

The Impact of SAT Math score, Targeted Multimedia Module completion, Gender and the interaction SAT Math & Targeted Module on student test score performance

Predictors	Model 1 B (SE)	Model 2 B (SE)
SAT Math Score	0.26*** (0.04)	0.32* (0.05)
Completed Targeted Multimedia Modules	0.090** (0.03)	0.16* (0.07)
Female	0.18** (0.07)	0.19* (0.07)
URM	0.17* (0.08)	0.11* (0.07)
SATMOD		-.0019 * (0.00)
N	1224	1224
R^2	0.11	0.11

Note. *p <0.05 **p<0.01 ***p<0.001. Dependent Variable: Mean score on test questions related to TMM content. Model 1: The model includes fixed effects for module topic. Model 2: The model also includes fixed effects for module topic and a variable for SATMOD (MATH SAT * Received Targeted Multimedia Module). All continuous variables were standardized.

3.4 Analysis 4: Comparing the effect of TMM completion on test performance by incoming SAT Math score, URM status and Gender.

Table 2

The influence of SAT Math score, Completion of TMM, Gender and the interaction SAT Math X Module completion (SATMOD) on student test score performance

Predictors	Math SAT Scores (below 650)	
	B	*B*
	(SE)	(SE)
	0.16***	0.21***
SAT Math Score	(0.04)	(0.06)
	0.22**	0.21**
Completed Targeted Multimedia Modules	(0.07)	(0.07)
	0.21**	0.21**
Female	(0.08	(0.08)
	0.12	0.12
URM	(0.08)	(0.08)
		-0.34
SATMOD		(0.03)
N	690	690
R^2	0.09	0.10

Figure 1. T test comparison of TMM completion on student performance by module topic.
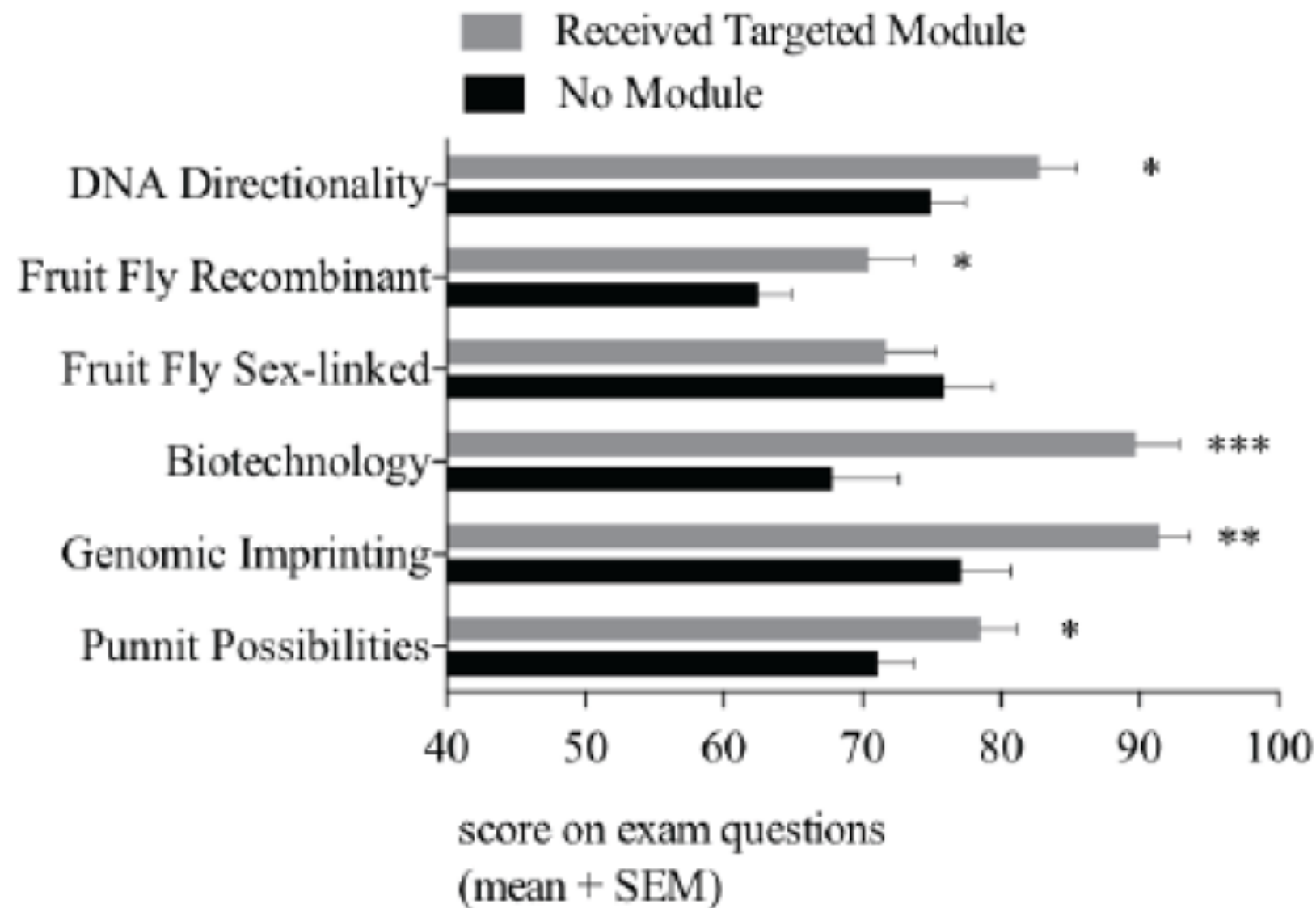
Note. *p <0.05, **p <0.01, ***p<0.001. Influence of individual TMMs on student performance by topic.

| Group | Math SAT ≥650 | | | | Math SAT 550-650 | | | | Math SAT <550 | | | |
| | No Module | | Targeted Multimedia Module | | No Module | | Targeted Multimedia Module | | No Module | | Targeted Multimedia Module | |
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Male URM	0.83 (o=6)	0.21	0.93 (o=6)	0.16	0.67 (o=48)	0.31	0.76* (o=42)	0.22	0.62 (o=32)	0.33	0.77* (o=28)	0.23
Female URM	1 (0=4)	0	1 (o=2)	0	0.74 (o=104)	0.27	0.83** (o=106)	0.19	0.73 (o=76)	0.28	0.83** (o=80)	0.20
Male non-URM	0.84 (o=56)	0.23	0.83 (o=52)	0.19	0.79 (o=136)	0.25	0.76 (o=128)	0.27	0.66 (o=44)	0.31	0.74 (o=34)	0.26
Female non-URM	0.84 (o=34)	0.16	0.86 (o=50)	0.18	0.77 (o=166)	0.27	0.80 (o=166)	0.25	0.72 (o=84)	0.28	0.73 (o=78)	0.27

Note. *p <0.05 **p<0.01. T-test comparison of student performance showing mean & standard deviation for Male URMs, Female URMs, Male non-URMs and Female non-URMs. Students were also grouped according to Math SAT score. (o = # of observations)

TMM Topics	
Section 1	Section 2
Basic chemistry (*Avagadro's number, Acids and Bases & pH and buffers*)	Basic chemistry (*Avagadro's number, Acids and Bases & pH and buffers*)
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RRM vs TMM	
Section 1	Section 2
RRM cell cycle regulation (*Cell Cycle Readings*)	TMM cell cycle regulation (*Cancer & Viruses*)
TMM oxidation and reduction (*Energetics*)	RRM oxidation & reduction (*Energetics Readings*)

3.6 Analysis 6: The effect of RRM completion on student test performance.

Table 4

Influence of TMM vs. RRM modules on student performance for content related questions

Predictors	RRM vs. No Module	RRM vs. TMM
	B	B
	(SE)	(SE)
Average SAT Math	0.24***	0.37***
	(0.04)	(0.06)
Completed Required Reading Modules	0.12	-0.055
	(0.07)	(0.11)
Female	0.13	0.052
	(0.08)	(0.011)
URM	0.02	-0.27*
	0.77	(0.13)
N	612	612
R^2	0.11	0.11

Note. **p <0.01 ***p<0.001 Dependent Variable for Model 1: Mean score on test questions related to RRMs (control=No Module).Model 1: The model includes fixed effects for RRM topics. Dependent Variable for Model 2: Mean score on test questions related to RRMs (control=TMM). Model 2: The model includes fixed effects for all TMM & RRM shared topics

Table 5.

Impact of Targeted Multimedia Module completion on student test score performance compared to Required Readings Module completion. Results are grouped by Math SAT score and Gender/URM status.

Group	Math SAT ≥650 Completed Targeted Module		Math SAT ≥650 Completed Readings Module		Math SAT 550-650 Completed Targeted Module		Math SAT 550-650 Completed Readings Module		Math SAT <550 Completed Targeted Module		Math SAT <550 Completed Readings Module	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Male URM	1.0 (o=4)	0.1	0.94 (o=4)	0.06	0.78 (o=36)	0.19	0.73 (o=24)	0.22	0.75 (o=24)	0.21	0.70 (o=16)	0.23
Female URM	N/A	N/A	N/A	N/A	0.79 (o=68)	0.17	0.75 (o=72)	0.15	0.81 (o=48)	0.14	0.73 * (o=56)	0.18
Male non-URM	0.88 (o=40)	0.23	0.85 (o=32)	0.21	0.78 (o=96)	0.20	0.80 (o=80)	0.18	0.67 (o=36)	0.21	0.72 (o=16)	0.16
Female non-URM	0.73 (o=12)	0.23	0.86** (o=44)	0.12	0.73 (o=96)	0.18	0.80** (o=140)	0.18	0.71 (o=60)	0.16	0.70 (o=48)	0.22

*p <0.05 **p<0.01 T-test comparison of student performance showing mean & standard deviation for Male URMs, Female URMs, Male non-URMs and Female non-URMs. Students were also grouped according to Math SAT score.

Qualitative response: Student opinion survey of TMMs

Questions	No Opinion	Strongly Disagree	Disagree	Agree	Strongly Agree
1. Completion of the TMMs helped me perform better on the final exam.	.06	.02	.09	.67	.16
2. During the final exam I found myself thinking about information I learned in the TMMs.	.05	.02	.14	.61	.17
3. I know that there were questions on the final exam that I would not have been able to answer correctly had I not completed the TMMs.	.09	.03	.14	.51	.23
4. I felt that I learned more from the TMMs than I did from reading the textbook.	.10	.08	.24	.38	.20
5. I found the TMMs to be interesting.	.06	.02	.09	.68	.16
6. I found the TMMs to be informative.	.03	.02	.03	.67	.26
	Very Negative	Negative	Neutral	Positive	Very Positive
7. Overall, how would you rate your experience with the online modules used in this course?	.01	.03	.22	.53	.22

Note. Student response rates for each question are shown in parentheses.

HIGHLIGHTS

- Targeted modules helped level scores for at risk URM students in an introductory biology course.

- Targeted Modules increase performance in male and female minority students with low SAT Math scores.

- Non-URM students with high SAT scores receive greater benefit from textbook style online modules.

- Targeted Modules are more effective than textbook-based modules for at-risk minority females.