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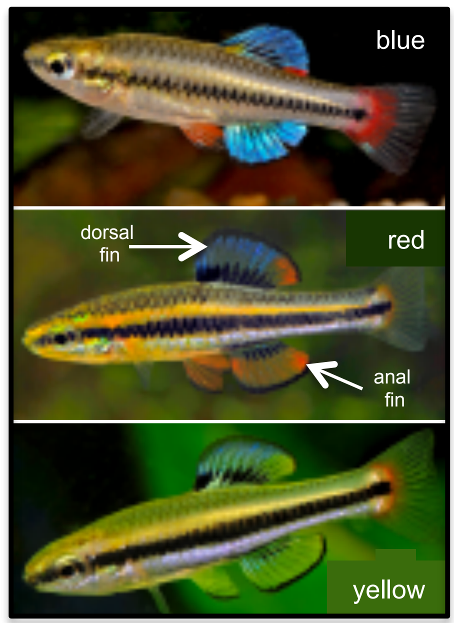
DATA Nugget

Why so blue? The determinants of color pattern in killifish, Part II
Featured scientist: Becky Fuller from The University of Illinois

In Part 1, you examined the effects of genetics and environment on anal fin color in male bluefin killifish. The data from Becky's experiment showed that both genetics and environment work together to determine whether male offspring had blue, yellow, or red anal fins. You will now examine how the father's genetics, specifically their fin color pattern, affects anal fin color in their sons. When we factor in the genetics of the father, and not just the population he came from, does this influence our interpretation of the data?

Research Background: Effect of paternal genetics on male offspring anal fin color

For her experiment, Becky collected male and female fish from both a swamp (26 Mile Bend) and a spring (Wakulla) population. Most of the males in the swamp have blue anal fins, but some have red or yellow. Most of the males from the spring have red or yellow anal fins, but some have blue. Becky decided to add data about the father's fin color pattern into her existing analysis from Part 1 to see how it affected her interpretation of the results.



The color polymorphism in bluefin killifish – males display anal fins in blue, red, or yellow. Photos by Tony Terceira.

In Part 1, Becky was looking at the genetics from the population level. Looking at the data this way, we saw parents from the 26 Mile Bend swamp population were more likely to have sons with blue anal fins than parents from the Wakulla spring. Parents from the 26 Mile Bend were also much more likely to have sons with higher levels of plasticity, meaning they responded more to the environment they were raised in. This means there was a big difference between the proportion sons with blue anal fins in the clear and brown water treatments.

Bringing in the color pattern of the fathers now allows Becky to look at the genetics from both the population and the individual level. From both the swamp and spring population, Becky collected males of all colors. Becky measured the color pattern of the fathers and recorded the color of their anal fins and the rear part of their dorsal fins. *She used males that were red on the rear portion of the dorsal fin with a blue anal fin (rb),*

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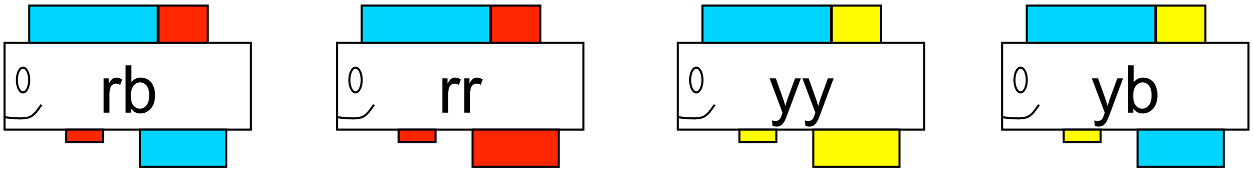
males that were red on both fins (rr), males that were yellow on both fins (yy), and males that were yellow on the rear portion of the dorsal fin with blue a blue anal fin (yb).



She randomly assigned half of each father's offspring to one of the water treatments, either clear or brown water. Once the sons developed their fin colors, she recorded the anal fin color. This experimental design allowed her to test whether sons responded differently to the treatment depending on the genetics of their father. She thought that the anal fin color of the sons would be inherited genetically from the father, but would also respond plastically to the environment they were raised in. She predicted fathers with blue anal fins would be more likely to have sons with blue anal fins, especially if they were raised in the brown water treatment. She also predicted that fathers with red and yellow anal fins could have sons with blue anal fins if they were raised in the brown water treatment, but not as many as the blue fathers.

Scientific Question: Is male anal fin color determined by genetics, environment, or both?

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Becky in the field, with her colleague Katy, collecting fish in Wakulla Spring.

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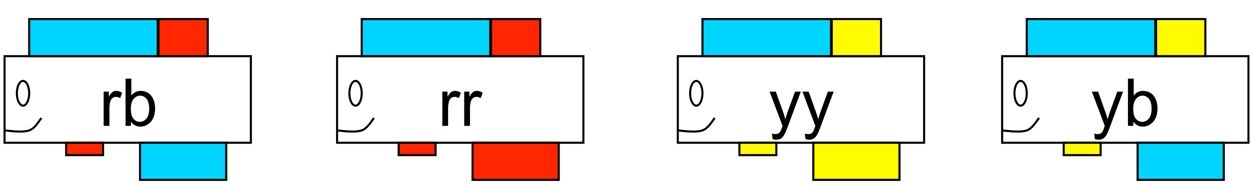
Scientific Data:

Use this information to complete the tables below, and use the data to answer the scientific question:

Father #	Father's Color Pattern	Father's Anal Fin Color	Parent Population	Water Treatment	Total # of Sons	Total # of Sons with Blue Anal Fins	Proportion Sons w/ Blue Anal Fins
1	rb		Wakulla	clear	10	0	
2	rb		Wakulla	clear	33	1	
3	rr		Wakulla	clear	32	0	
4	rr		Wakulla	clear	26	0	
5	yb		Wakulla	clear	15	0	
6	yb		Wakulla	clear	25	0	
7	yy		Wakulla	clear	28	0	
8	yy		Wakulla	clear	17	0	
9	yy		Wakulla	clear	11	0	
1	rb		Wakulla	brown	16	0	
2	rb		Wakulla	brown	23	0	
3	rr		Wakulla	brown	26	0	
4	rr		Wakulla	brown	31	2	
5	yb		Wakulla	brown	31	1	
6	yb		Wakulla	brown	23	1	
7	yy		Wakulla	brown	42	0	
8	yy		Wakulla	brown	50	1	
9	yy		Wakulla	brown	14	0	
10	rb		26 Mile Bend	clear	29	1	
11	rb		26 Mile Bend	clear	21	0	
12	rr		26 Mile Bend	clear	17	1	
13	rr		26 Mile Bend	clear	16	0	
14	yb		26 Mile Bend	clear	31	1	
15	yb		26 Mile Bend	clear	34	6	
16	yy		26 Mile Bend	clear	14	0	
17	yy		26 Mile Bend	clear	31	0	
10	rb		26 Mile Bend	brown	38	11	
11	rb		26 Mile Bend	brown	6	3	
12	rr		26 Mile Bend	brown	24	2	
13	rr		26 Mile Bend	brown	17	3	
14	yb		26 Mile Bend	brown	20	5	
15	yb		26 Mile Bend	brown	28	5	
16	yy		26 Mile Bend	brown	25	0	
17	yy		26 Mile Bend	brown	42	3	



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Parent Population	Water Treatment	Father's Color Pattern	Average Proportion Sons w/ Blue Anal Fins	Standard Deviation (SD)	Sample Size (N)	Standard Error (SE)
Wakulla	clear	rb		0.021	2	0.015
Wakulla	clear	rr		0	2	0
Wakulla	clear	yb		0	2	0
Wakulla	clear	yy		0	3	0
Wakulla	brown	rb		0	2	0
Wakulla	brown	rr		0.046	2	0.032
Wakulla	brown	yb		0.008	2	0.006
Wakulla	brown	yy		0.012	3	0.007

Parent Population	Water Treatment	Father's Color Pattern	Average Proportion Sons w/ Blue Anal Fins	Standard Deviation (SD)	Sample Size (N)	Standard Error (SE)
26 Mile Bend	clear	rb		0.024	2	0.017
26 Mile Bend	clear	rr		0.042	2	0.029
26 Mile Bend	clear	yb		0.102	2	0.072
26 Mile Bend	clear	yy		0	2	0
26 Mile Bend	brown	rb		0.149	2	0.105
26 Mile Bend	brown	rr		0.066	2	0.047
26 Mile Bend	brown	yb		0.051	2	0.036
26 Mile Bend	brown	yy		0.051	2	0.036

**Standard deviation (SD) tells us about the amount of variation in the data. A large SD means there is a lot of variation around the mean, while a small SD means the data points all fall very close to the mean. Standard error (SE) is SD divided by the square root of the sample size (N), and tells us how confident we are in our estimate of the mean. A large SE means we are not very confident, while a small SE means we are more confident.*

What data will you graph to answer the question?

Independent variable(s): ____

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Dependent variable(s): ____

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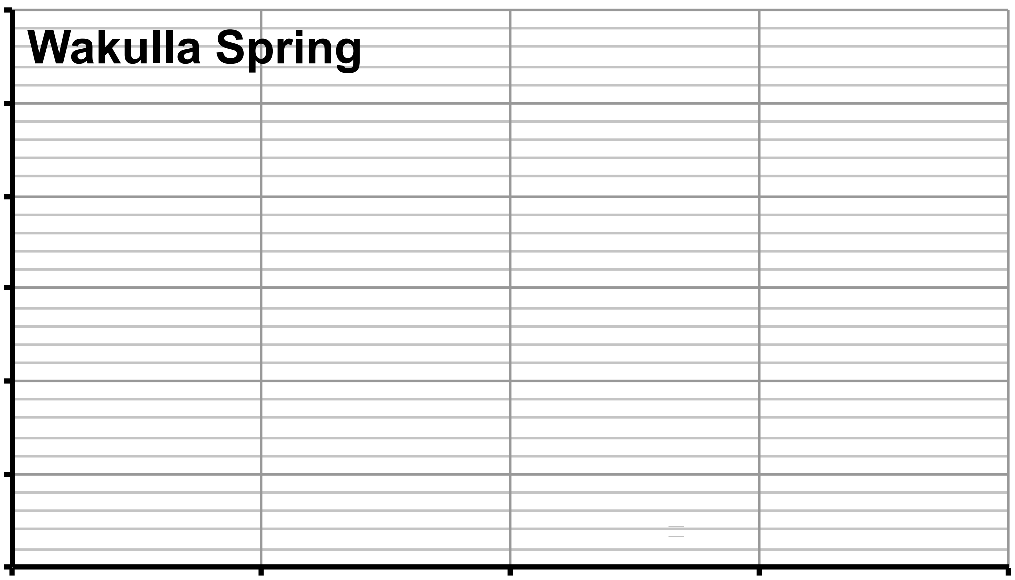
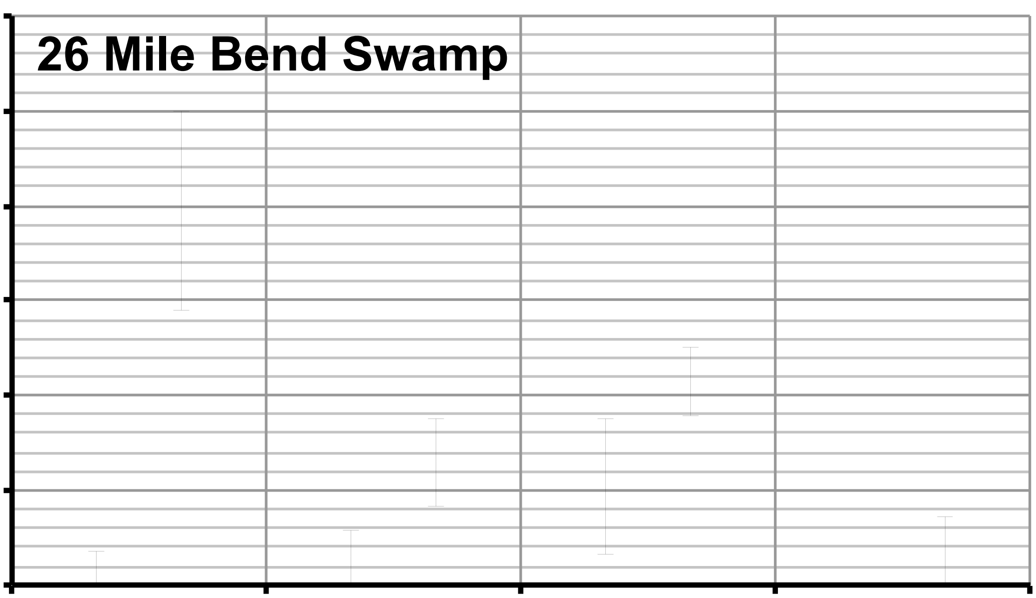
Draw your graphs below: Identify any changes, trends, or differences you see in your graph. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.





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Interpret the data:

Make a claim that answers the scientific question.

What evidence was used to write your claim? Reference specific parts of the tables or graphs.

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about the effect of paternal fin color pattern on male offspring anal fin color.

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Did the data support Becky’s hypothesis? Use evidence to explain why or why not. If you feel the data was inconclusive, explain why.

Your next steps as a scientist: Science is an ongoing process. What new question do you think should be investigated? What future data should be collected to answer your question?