SCIENCE 3D

THE REAL BLACK PANTHER

In this packet, sample student answers are provided in red and notes to teacher are in blue.

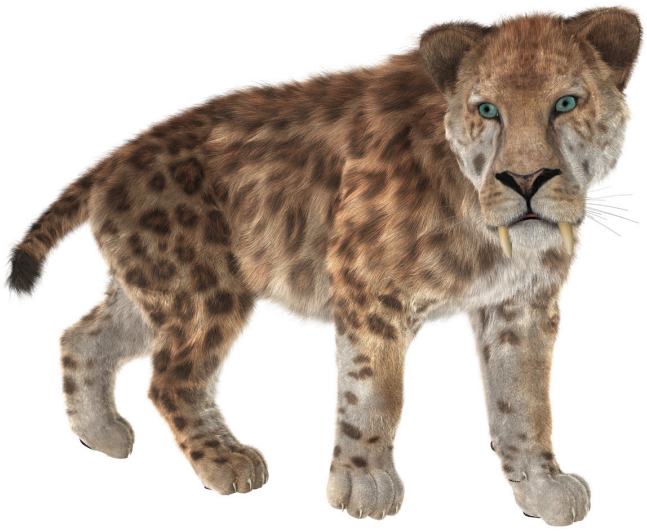
In this **Science Mission**, students will begin by using Punnett squares to investigate genetics and work with simple ratios. Next, they will use data to investigate how having a black or a yellow coat influences the hunting success of leopards. Then, they will make predictions about how these results inform the relative abundance of traits in the population and how the population might change if there was a change in the environment. Finally, students will model natural selection in a leopard population.

ACTIVITY I: WHAT GENE IS THAT?

Before we are ready to help with the Black Panther investigation, we need to practice some Punnett squares. Understanding the types of offspring that parents with different genes can produce, helps us make guesses about how genes control traits.

Let's pretend that a fictional animal, called a saberlion, could have green or brown eyes. The color of a saberlion's eyes are determined by the combination of alleles at one gene. The allele for green eyes (labeled as "A") is **dominant**. The allele for brown eyes (labeled "a") is **recessive**. In saberlions, the combination of these two alleles creates different genotypes. Homozygous dominant (AA) saberlions have green eyes. Heterozygous (Aa) saberlions also have green eyes. Homozygous recessive (aa) saberlions have brown eyes. Saberlions always produce four offspring when they reproduce.

Genotype	Phenotype
AA	green eyes
Aa	green eyes
aa	brown eyes



1. Use the information in the paragraph and chart above to fill in the following Punnett squares with the possible genotypes of offspring (AA, Aa, or aa). Then use this information to determine the number of offspring with different phenotypes (green eyes or brown eyes). The first one has been completed for you as an example.

Punnett Square 1: Cross homozygous dominant with homozygous dominant

	A	A
A	**AA**	**AA**
A	**AA**	**AA**

Number of Green Eyes 4

Number of Brown Eyes 0

Punnett Square 2: Cross heterozygous with homozygous dominant

	A	a
A	AA	Aa
A	AA	Aa

Number of Green Eyes 4

Number of Brown Eyes 0

Punnett Square 3: Cross heterozygous with heterozygous

	A	a
A	AA	Aa
a	Aa	aa

Number of Green Eyes 3

Number of Brown Eyes 1

Punnett Square 4: Cross heterozygous with homozygous recessive

	A	a
a	Aa	aa
a	Aa	aa

Number of Green Eyes 2

Number of Brown Eyes 2

Punnet Square 5: Cross homozygous recessive with homozygous recessive

	a	a
a	aa	aa
a	aa	aa

Number of Green Eyes 0

Number of Brown Eyes 4

Possible extension: In the example above, saberlions produced only four offspring. This made the math very easy. To enhance math skills, you could add the following exercise that helps students understand ratios. Have students use the information that they provided in the first activity to fill in the ratios. Then have them use these ratios to fill in Table 1 below by calculating how many offspring of each eye color would be produced if there were a) 16 offspring produced and b) 200 offspring produced.

Table 1. Proportion of phenotypes from crosses of different genotypes of saberlion

Parent genotypes	Offspring eye color ratio green:brown	Decimal percent green eyes	Decimal percent brown eyes	Number of offspring with each eye color; 16 offspring produced		Number of offspring with each eye color; 200 offspring produced	
		Green	Brown	Green	Brown	Green	Brown
AA, AA	4:0	1.0	0	16	0	200	0
AA, Aa	4:0	1.0	0	16	0	200	0
Aa, Aa	3:1	0.75	0.25	12	4	150	50
Aa, aa	1:1 (or 2:2)	0.5	0.5	8	8	100	100
aa, aa	0:4	0	1.0	0	16	0	200

Shaaz has gathered information on the leopard cubs in Nagarhole National Park for years. The information he has collected is presented in the table below. Use these data to figure out more about the genetics of black panthers.

Table 2. Coat colors of leopard parents and their offspring

Litter number	Mother	Father	Number of yellow cubs	Number of black cubs
1	black	black	0	3
2	black	black	0	4
3	black	yellow	4	0
4	black	yellow	3	0
5	yellow	black	3	0
6	yellow	black	2	2
7	yellow	yellow	3	0
8	yellow	yellow	2	0
9	yellow	yellow	3	0
10	yellow	yellow	4	0
11	yellow	yellow	1	0
12	yellow	yellow	3	1

2. Use the information in the table above to determine if melanism in leopards (black panthers) is recessive or dominant. Provide evidence from Table 2 and your work on saberlions to support your answer.

Black panthers are the result of a recessive allele. The best evidence for this is that two yellow panthers produced a black cub and yellow cubs, but two black parents only produced black cubs.

Students may also point out that the ratios of cubs by litters match those that they determined for the eyes of the imaginary animal in the first part of the activity, with the proportion of cubs of litters 6 and 12 really helping match things.

3. Look at litter number 6. What can you tell about the genes the yellow colored mother has based on the colors of her cubs? Provide support for your statement.

The mother has a yellow allele and a melanistic (black panther) allele. The evidence for this is that when they reproduced, half of the offspring were black. This is what is expected when a male with two alleles for black coats mates with a yellow-colored leopard with one black allele (recessive) and one yellow color allele (dominant).

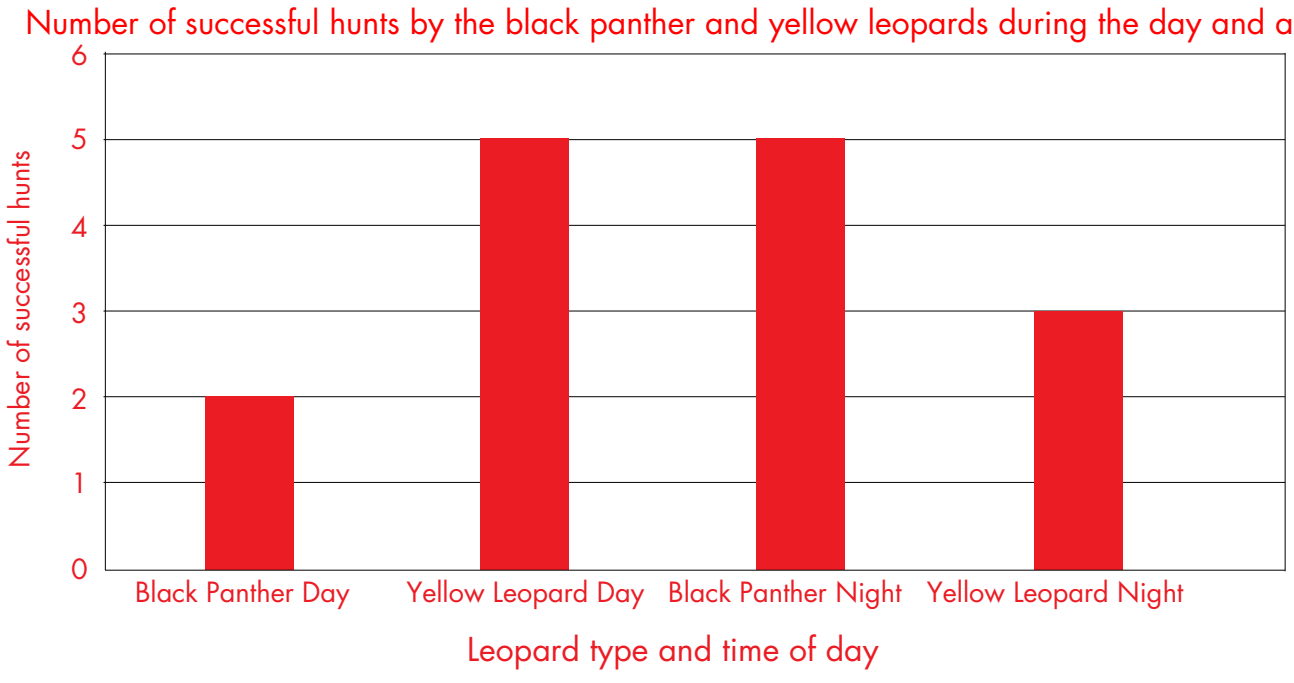
ACTIVITY 2: BLACK PANTHER VS YELLOW LEOPARD

To find out if the black panther was better or worse at hunting than the yellow leopard, Shaaz watched both Saya and yellow leopards hunt during the day and at night. He recorded if the hunt failed or if it succeeded. **Count** the number of successes for the black panther and yellow leopards. **Record** your data in Table 3.

Table 3. Result of hunts by the black panther and a yellow leopard during the day and at night

Hunt Number	Black panther (Day)	Black panther (Night)	Yellow leopard (Day)	Yellow leopard (Night)
1	Fail	Fail	Fail	Success
2	Fail	Fail	Fail	Fail
3	Fail	Success	Success	Fail
4	Success	Fail	Success	Fail
5	Fail	Success	Fail	Fail
6	Fail	Success	Success	Success
7	Success	Fail	Success	Fail
8	Fail	Fail	Fail	Fail
9	Fail	Success	Success	Success
10	Fail	Success	Fail	Fail
Total Successes	2	5	5	3

1. **Make** a bar graph of the number of successful hunts for the different types of leopards during the day and night. Title your graph a title and label the axes.



2. **Compare** how well the black panther and yellow leopard hunt during the day. Did their color matter? Use evidence from your graph.

Yes, color mattered. The black panther isn't very good at hunting during the day. It only caught prey one time in ten tries. The yellow leopard is a better daytime hunter. It caught prey five times in ten tries.

3. **Compare** how well the black panther hunted during the day and at night. Did the time of day he hunted matter? Use evidence from your graph.

Yes, time of day mattered. The black panther isn't very good at hunting during the day. It only caught prey one time in ten tries. He is good at hunting at night. He caught prey five times in ten tries.

4. **Describe** if the results of the hunting study help explain the times of day that the black panther likes to hunt.

Yes, this helps explain why the black panther hunts when he does. He hunts at night because that is when he is better at hunting. He sleeps when he is bad at hunting, or during the day.

5. **Predict** the consequences for the black panther having a black coat if most leopard prey were able to hide in places where leopards can't catch them during the night. Would this help or hurt his chances of survival? Support your answer with evidence from table 3.

I predict that the black panther would have a harder time surviving because he is better at hunting at night than during the day. If there were no prey to catch at night, it would be hard for him to get enough to eat. Not getting enough to eat would reduce his chances of surviving.

6. **Predict** what would happen to the proportion of black panthers in the population through time if most leopard prey learned to hide in places where leopards can't catch them during the night. Explain why you made this prediction.

Through time there would be fewer black panthers in the population. Because black panthers would have a hard time finding food, they would be less likely to survive and reproduce. Through time, the allele for having a black coat would become less common.

Note: If students answered in question #4 that there would be no change in the survival of the black panther, they might say here that because black panthers continue to survive at the same rate, there would be no change in the proportion of black panthers. While not correct, this would logically follow from their prediction in #4 and should be given partial credit.

ACTIVITY 3: MODELING EVOLUTION

For this activity, have students work in teams to check calculations. Allow students to use calculators but make sure that they show their work.

One way to understand natural selection is to use mathematical models. These models help us make predictions about what might happen if conditions were to change. You are going to create a simple model to see what might happen if conditions were to change in the world of the Black Panther.

This is a simplified model, meaning some parts will not represent the way things work in nature completely accurately. But, it will be close enough to learn about what might happen to the population. The rules are as follows:

- Start with a population of 300 leopards. Of these, 250 are yellow color and 50 are black panthers.
- In the first part of every generation, before reproduction, leopards and black panthers survive or die based on their ability to catch enough food. Assume black panthers are not as good hunters as yellow colored leopards. So, 80% of yellow color leopards survive each year but only 70% of black panthers survive. When calculating how many individuals survive, round to the nearest whole number. Always round 0.5 up.
  - To calculate the number of black panthers at the next time step (we can represent this with the symbol B_{t+1}) we use the equation:
    $B_{t+1} = 0.7 \bullet B_t$ where B_t is the number of black panthers alive just before survival.
  - Based on this, complete the equation for yellow leopards:

$$Y_{t+1} = \underline{0.8} \bullet \underline{Y_t}$$

- Once survival is completed, leopards reproduce. Each panther has three offspring each year.
  - For black panthers: The total number of cubs produced by black panthers = $B_{t+1} \bullet 3$
  - For yellow leopards: The total number of cubs produced by yellow leopards = $Y_{t+1} \bullet 3$
- For black panthers, 25% of offspring are black and 75% are yellow (remember, even though black panthers only produce black panther cubs if they mate with another black panther, they usually produce yellow leopard cubs when they mate with yellow leopards). When filling out your table, remember to round the number of offspring of each type to the nearest whole number. If the number ends in 0.5, round up.
  - For black panthers
    - The number of black cubs produced by black panthers = the total number of cubs • 0.25
    - The number of yellow cubs produced by black panthers = the total number of cubs • 0.75

- For yellow leopards, 90% of their cubs are yellow and 10% are black. If there is only one individual left to reproduce, it produces a yellow offspring. Remember to round the number of offspring of each type to the nearest whole number. If the number ends in 0.5, round up.
  - For yellow leopards:
    - The number of yellow cubs produced by yellow leopards = the total number of cubs • 0.10
    - The number of yellow cubs produced by yellow leopards = the total number of cubs • 0.90

- After cubs are produced, we will assume that black cubs and yellow cubs survive at the same rate. But, only 25% of cubs survive to the next generation.
  That means that the number of cubs that survives = number produced • 0.25.

- After reproduction, the cycle starts again.

1. Based on the rules provided, **complete** the table and calculations for Generation
   2. The Generation 1 table and calculations have been completed as a guide.

Generation 1

	Black panther	**Yellow leopard**	**Proportion of black panthers in population**
Population at start	B_t = 50	Y_t = 250	0.17 $[B_t / (B_t + Y_t)]$
Number that survive	B_{t+1} = 35	Y_{t+1} = 200	0.15 $[B_{t+1} / (B_{t+1} + Y_{t+1})]$
Number of cubs produced	Total cubs: 105	Total cubs: 600	————
	Yellow cubs: 79	Yellow cubs: 540	
	Black cubs: 26	Black cubs: 60	
Number black cubs that survive	7	15	————
Number yellow cubs that survive	20	135	————
Total individuals in next generation (surviving adults + surviving cubs)	57 (hint: surviving black panther adults + black cubs from black panthers + black cubs from yellow leopards)	355	0.14

Generation 1 calculations:

50 black panthers • 0.70 survival = 35 remaining black panthers

35 black panthers • 3 offspring/panther = 105 cubs
105 cubs • 25% black cubs = 26.25; round to 26
105 cubs • 75% yellow cubs = 78.75; round to 79

26 black cubs • 0.25 survive = 6.5; round to 7
79 yellow cubs • 0.25 survive = 19.75; round to 20

250 yellow leopards • 0.80 survival = 200 yellow leopards
200 yellow leopards • 3 offspring/panther = 600 cubs
600 cubs • 10% black cubs = 60 cubs
600 cubs • 90% yellow leopards cubs = 540 cubs

60 cubs • 0.25 survive = 15 surviving cubs
540 cubs • 0.25 survive = 135 surviving cubs

Next generation:
35 remaining black panther adults + 7 black cubs from black panthers + 15 black cubs from yellow leopards = 57 black panthers

200 remaining yellow leopard adults + 20 yellow cubs from black panthers + 135 yellow cubs from yellow leopard = 355 yellow leopards

$$\frac{\text{57 black panthers}}{\text{421 total leopards}} = 0.14$$

Generation 2

	Black panther	Yellow leopard	Proportion of black panthers in population
Population at start	57	355	0.14
Number that survive	40	284	0.12
Number offspring produced (black, yellow)	120 total cubs 30 black 90 yellow	852 total cubs 85 black 767 yellow	_____
	Total	Total	
Number black cubs that survive	8	21	_____
Number yellow cubs that survive	23	192	_____
Total individuals in next generation (surviving adults + surviving cubs)	69	499	0.12

Generation 2 calculations:

57 black panthers • 0.70 survival = 39.9 remaining black panthers; round to 40

40 black panthers • 3 offspring/panther = 120 cubs
120 cubs • 25% black cubs = 30
120 cubs • 75% yellow cubs = 90

30 black cubs • 0.25 survive = 7.5; round to 8
90 yellow cubs • 0.25 survive = 22.5; round to 23

355 yellow leopards • 0.80 survival = 284 yellow leopards
284 yellow leopards • 3 offspring/panther = 852 cubs
852 cubs • 10% black cubs = 85.2 black cubs; round to 85
852 cubs • 90% yellow leopards cubs = 766.8 yellow cubs; round to 767

85 black cubs • 0.25 survive = 21.25 surviving black cubs; round to 21
767 yellow cubs • 0.25 survive = 191.75 surviving yellow cubs; round to 192

Next generation:
40 remaining black panther adults + 8 black cubs from black panthers + 21 black cubs from yellow leopards =
69 black panthers

284 remaining yellow leopard adults + 23 yellow cubs from black panthers + 192 yellow cubs from yellow leopards = 499 yellow leopards

$$\frac{\text{69 black panthers}}{\text{568 total leopards}} = 0.12$$

Extend the lesson: The STEM Project for this unit features programming Google or Excel Spreadsheets to create a program to simulate the dynamics that students worked out by hand in this lesson.

2. **Describe** the trend in the overall population size of leopards of both color types. What would happen to the population if you kept running the simulation?

The population is getting larger. I think it would continue increasing quickly.

3. **Describe** what is happening to the proportion of black panthers in the population. Explain why you think the proportion of black panthers and yellow leopards is changing. Cite evidence from the tables you completed.

The proportion of black panthers in the population is decreasing even though their numbers are increasing. This is because the adult black panthers have lower survival than yellow leopards. Students may also notice that after reproduction, the proportion of black panthers goes up a little bit before dropping even further in the next generation after the survival step.

4. **Predict** what you think would happen to the population growth and proportion of black panthers in the population if the survival rate of black panthers increased to 95%. Explain.

The leopard population would increase very rapidly because more adult leopards would survive and produce more cubs. The proportion of black panthers in the population would increase because they survive better than yellow leopards.

Continue the exploration of modeling and computing to help simulate populations. Check out the Engineering and Computing Activity in the *Black Panther STEM Projects*!