

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 **STEM Project**, students will expand their computing skills by following step-by-step instructions to code a model of natural selection into a database program (e.g. Microsoft Excel). They will use the model to investigate how changes in variables will affect predicted outcomes. *Note: The teacher materials allow you to provide students with as much information as needed to modify the difficulty of the programming.*



Scientists use many types of models. Some models are physical, and represent objects in the real world. An example is a model of a cell that allows people to see very small things that cannot be seen by the human eye. Similarly, a physical model of the environment can make huge objects or areas small enough to easily see and manipulate. A globe is one example. Alternatively, some models are mathematical. These models use equations to represent processes that occur in nature. They can be used to predict the behavior of systems or organisms. Computers can help make complex mathematical calculations. Scientists can also use computers to create simulation models. These are digital models that let us predict what might happen in the real world!

Let's use a computer spreadsheet to create a simple simulation model of evolution to explore the possible benefits and costs of a leopard having a black coat. This model will not be completely realistic or accurate, but it will provide some ideas on how evolution might work.

The first step is to create the mathematical equations that we will use to represent processes. The next step is to write the code into a computer program. For this exercise, we will use a spreadsheet for our computer program. The final step is to use the program to explore different scenarios.

Here is the simplified scenario we will use in our model:

1. A population of leopards has individuals with black coats and yellow coats.
2. The number of adult black panthers at the start of each year is called the "Number of Black Adults." At the start of the first year, there are 50 black adults.
3. The number of adult yellow panthers at the start of each year is called the "Number of Yellow Adults." At the start of the first year, there are 250 yellow adults.
4. The color of a leopard's coat is controlled by one gene.
5. The allele for a yellow coat is dominant. The allele for a black coat is recessive.
6. In each year, 70% of black panthers survive to reproduce that year (Adult Survival Rate Black = 0.7).
7. In each year, 80% of yellow leopards survive to reproduce that year (Adult Survival Rate Yellow = 0.8).
8. Every year, each individual that starts the year produces three offspring (cubs per adult = 3).
9. Black panthers' cubs are 25% black (Proportion black cubs by black adults = 0.25) and 75% yellow (Proportion yellow cubs by black adults = 0.75).
10. Yellow panthers' cubs are 10% black (Proportion black cubs from yellow adults = 0.10) and 90% yellow (Proportion yellow cubs from yellow adults = 0.90).
11. Twenty-five percent of black panther cubs survive to be an adult in the next year (Black Cub Survival Rate = 0.25).
12. Twenty-five percent of yellow leopard cubs survive to be an adult in the next year (Yellow Cub Survival Rate = 0.25).

ACTIVITY I: CREATING EQUATIONS

The next step of creating a model is to develop the equations that we need to program the computer. Use the symbols given in Table 1 to fill in equations 1-12 on the next page.

Table 1. Computer program equation spreadsheet

Description	Symbol	Value if Constant
Initial number of black panther adults at start of a generation	N_{BI}	-
Black panther adult survival rate	S_{AB}	0.70
Number of black panther adults that survive to reproduce	N_{BR}	-
Initial number of yellow leopard adults at start of a generation	N_{YI}	-
Yellow leopard adult survival rate	S_{AY}	0.80
Number of yellow leopard adults that survive to reproduce	N_{YR}	-
Total number of black panther cubs produced by adult black panthers	BC_B	-
Total number of yellow leopard cubs produced by adult black panthers	YC_B	-
Total number of black panther cubs produced by adult yellow leopards	BC_Y	-
Total number of yellow leopard cubs produced by adult yellow leopards	YC_Y	-
Total number of cubs produced by each adult	C_T	3
Proportion of black panther cubs produced by black panthers	$PC_{B,B}$	0.25
Proportion of yellow leopard cubs produced by black panthers	$PC_{Y,B}$	0.75
Proportion of black panther cubs produced by yellow leopards	$PC_{B,Y}$	0.10
Proportion of yellow leopard cubs produced by yellow leopards	$PC_{Y,Y}$	0.90
Survival rate of black panther cubs	S_{CB}	0.25
Survival rate of yellow leopard cubs	S_{CY}	0.25
Total number of yellow leopard cubs surviving to adulthood	N_{YC}	-
Total number of black panther cubs surviving to adulthood	N_{BC}	-
Number of black panther adults at end of generation (and start of next)	N_{BE}	-
Number of yellow leopard adults at end of generation (and start of next)	N_{YE}	-
Total number of leopards at end of generation (and start of next)	L_T	-

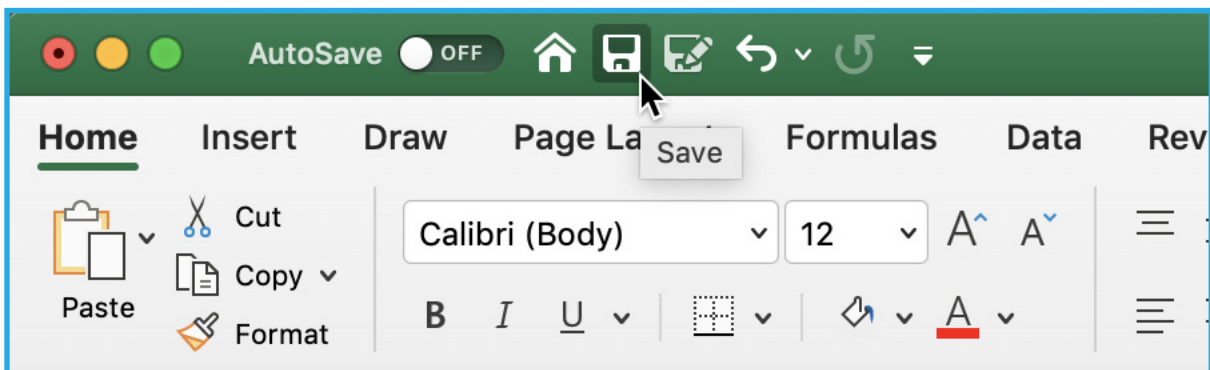
1. $N_{BR} = S_{AB} * N_{B_i}$
2. $N_{YR} = \underline{S_{AY} * N_{Y_i}}$
3. $BC_B = N_{BR} * C_T * PC_{B,B}$
4. $YC_B = \underline{N_{BR} * C_T * PC_{Y,B}}$
5. $BC_Y = \underline{N_{YR} * C_T * PC_{B,Y}}$
6. $YC_Y = N_{YR} * C_T * PC_{Y,Y}$
7. $N_{Y_C} = S_{CY} * (YC_B + YC_Y)$
8. $N_{BC} = \underline{S_{CB} * (BC_B + BC_Y)}$
9. $N_{B_E} = N_{BC} + N_{BR}$
10. $N_{Y_E} = \underline{N_{Y_C} + N_{Y_R}}$
11. $L_t = \underline{N_{B_E} + N_{Y_E}}$
12. Proportion of black panthers at the end of the generation = $\underline{N_{B_E}/L_t}$
We will call this PBP in the spreadsheet.

ACTIVITY 2: CREATING A SIMULATION PROGRAM

Our next step is to put these equations into a spreadsheet.

Step 1: Getting started

1. Open your spreadsheet program. In order to not lose your work, save your spreadsheet to your favorite folder. You can click the disk icon at the top of the page or click on File -> Save As.
2. Give the file the name "panther_simulation.xlsx" Make sure you save your sheet frequently while you work!



Step 2: Insert the constants

Within simulation programs it is useful to see what happens when values change in the model. This requires a place to save all of the constants that we might want to change.

1. In cells A1 to I1, enter the names of the symbols for the factors that have defined values in Table 1. Put the subscripts in parentheses.
2. Enter the values for each of these constants in cells A2 to I2.

	A	B	C	D	E	F	G	H	I
1	S(AB)	S(A _Y)	C(T)	PC(B,B)	PC(Y,B)	PC(B,Y)	PC(Y,Y)	S(CB)	S(CY)
2	0.7	0.8	3	0.25	0.75	0.1	0.9	0.25	0.25
3									

Step 3: Set up the headings

1. In Cell A5, enter the word "Generation." In the rows below this heading we will enter number of times the panthers go through a cycle of survival and reproduction.
2. Enter the symbols for the values that need to be calculated from questions 1-12 in Activity 1 in Cells B5 to N5.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	S(AB)	S(A _Y)	C(T)	PC(B,B)	PC(Y,B)	PC(B,Y)	PC(Y,Y)	S(CB)	S(CY)					
2	0.7	0.8	3	0.25	0.75	0.1	0.9	0.25	0.25					
3														
4														
5	Generation	NB(I)	NB(R)	NY(I)	NY(R)	BC(B)	YC(B)	BC(Y)	YC(Y)	N(YC)	N(BC)	NB(E)	NY(E)	L(T)
6														

3. Enter the numbers 1, 2, and 3 in cells A6, A7, and A8 respectively.
4. Click and hold on cell A6 and drag down to highlight cells A6-A8. Release the click.
5. Put the cursor in the lower right corner of cell A8 on the small black square.
6. Click and hold, then drag the cursor down through Cell A20 and release. It should look like this:

STEP 3 NUMBER 4

STEP 3 NUMBER 5 & 6

	A	B	C
1	S(AB)	S(AY)	C(T)
2	0.7	0.8	3
3			
4			
5	Generation	NB(I)	NB(R)
6	1		
7	2		
8	3		
9			

	A	B	5	Generation	NB(I)
1	S(AB)	S(AY)			
2	0.7	0.8			
3					
4					
5	Generation	NB(I)			
6	1				
7	2				
8	3				
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					

Step 4: Entering the equations

1. In cell B6 enter the starting number of black panthers in Activity 1 (50).
2. In cell D6 enter the starting number of yellow leopards in Activity 1 (250).
3. Fill in the equation to calculate NB_R in cell C6. Do this using the cell locations where you stored constants or where cells have the information you need. Here, and for the rest of the activity, if you are using one of the constants, put a \$ in front of the column number and a \$ in front of the row number. For cell C6, the formula should be:

= $\$A\$2*B6$

	A	B	C	D	E	F	G	H
1	S(AB)	S(AY)	C(T)	PC(B,B)	PC(Y,B)	PC(B,Y)	PC(Y,Y)	S(CB)
2	0.7	0.8	3	0.25	0.75	0.1	0.9	0.
3								
4								
5	Generation	NB(I)	NB(R)	NY(I)	NY(R)	BC(B)	YC(B)	BC(Y)
6	1	50	=A\$2*B6	250				
7	2							
8	3							
9	4							
10	5							

What's with the dollar signs? These tell the computer that you want to always look at cell A2, even if you copy the formula somewhere else. If there are no dollar signs before the row and column designations, then if you copy the formula and paste it somewhere else the computer will change the letter and row numbers to match the selected cell. So, if I copied this formula from Cell C6 (where it is written) and pasted it in Cell E12 (which I wouldn't do) then the formula would become $=A\$2\bullet D12$. You will see why writing the formula this way is important soon!

4. Fill in the equation to calculate BC_B in cell F6. Remember the dollar signs.

$$=C6*\$C\$2*\$D\$2$$

In the questions below, students are asked to develop their own equations. This activity is best done together as a class to ensure students have the correct equations before they are input on the computer. Have students work in groups to develop their ideas.

5. In the space below, **write out** the equation that you need to enter into cell G6 to calculate YC_B

$$=C6*\$C\$2*\$E\$2$$

6. **Enter** the equation you wrote above in Cell G6.
7. In the space below, **write out** the equation that you need to enter into cell E6 to calculate NY_R .

$$=\$B\$2*D6$$

8. **Enter** the equation you wrote above in Cell E6
9. In the space below, **write out** the equation that you need to enter into cell I6 to calculate YC_Y .

$$=E6*\$C\$2*\$G\$2$$

10. **Enter** the equation you wrote above in Cell I6
11. In the space below, **write out** the equation that you need to enter into cell H6 to calculate BC_Y .

$$=E6\bullet \$C\$2\bullet \$F\$2$$

12. **Enter** the equation from question 11 in Cell H6.

13. In the space below, **write out** equation below to calculate N_{yc} in cell J6. Notice the dollar signs and the parentheses to make sure the order of operations is correct!

$$=I\$2*(G6+I6)$$

14. **Enter** the equation you wrote above in Cell J6.

15. In the space below, **write out** the equation that you need to enter into cell K6 to calculate N_{bc}.

$$=\$H\$2*(F6+H6)$$

16. **Enter** the equation you wrote above in Cell K6.

17. In the space below, **write out** equation below to calculate N_{be} in cell L6.

$$=K6+C6$$

18. **Enter** the equation you wrote above in Cell L6.

19. In the space below, **write out** equation below to calculate N_{ye} in cell M6.

$$=J6+E6$$

20. **Enter** the equation you wrote above in Cell M6.

21. In the space below, **write out** equation to calculate L_t in cell N6.

$$=L6+M6$$

22. **Enter** the equation you wrote above in Cell N6.

23. **Enter** the equation below to calculate the proportion of black panthers in the population at the end of the generation.

$$=L6/N6$$

24. **Enter** the equation you wrote above in Cell O6. Label cell O5 as PBP.

At the end of the first generation your students table should look like this.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
1	S(AB)	S(AY)	C(T)	PC(B,B)	PC(Y,B)	PC(B,Y)	PC(Y,Y)	S(CB)	S(CY)							
2		0.7	0.8	3	0.25	0.75	0.1	0.9	0.25	0.25						
3																
4																
5	Generation	NB(I)	NB(R)	NY(I)	NY(R)	BC(B)	YC(B)	BC(Y)	YC(Y)	N(YC)	N(BC)	NB(E)	NY(E)	L(T)	PBP	
6		1	50	35	250	200	26.25	78.75	60	540	154.6875	21.5625	56.5625	354.6875	411.25	0.13753799
7		2														

Step 5: Set up the next generation

Now it's time to set up the second generation.

1. Copy cells B6 through O6.
2. Move the cursor to cell B7 and paste the values.
3. Delete the values in cell B7 and the value in D7. To do this, highlight the cell and hit the DELETE key. The rest of the values in the row should turn into 0s, except for O7 which becomes #DIV/0!.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
1	S(AB)	S(AY)	C(T)	PC(B,B)	PC(Y,B)	PC(B,Y)	PC(Y,Y)	S(CB)	S(CY)							
2		0.7	0.8	3	0.25	0.75	0.1	0.9	0.25	0.25						
3																
4																
5	Generation	NB(I)	NB(R)	NY(I)	NY(R)	BC(B)	YC(B)	BC(Y)	YC(Y)	N(YC)	N(BC)	NB(E)	NY(E)	L(T)	PBP	
6		1	50	35	250	200	26.25	78.75	60	540	154.6875	21.5625	56.5625	354.6875	411.25	0.13753799
7		2		0		0	0	0	0	0	0	0	0	0	0	#DIV/0!
8		3														

4. Now we need to enter a formula for the starting number of black panthers and yellow leopards in generation 2. Enter the formula “=L6” into cell B7. This sets the starting number of black panthers to the number that survived generation 1. In Cell D7, enter “=M6” to do the same for yellow leopards.

Step 6: Complete the simulations

Now, we need to see what will happen to the population in future generations. If you have put your formulas in correctly, this is easy!

1. Select cells B7 through O7.
2. Click and hold with the cursor on the black square in the lower right corner of cell O7.
3. Drag the cursor down to select through cell O20.
4. Release the cursor. Values should populate the entire sheet.

STEP 6 NUMBER 1-3

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	S(AB)	S(A _Y)	C(T)	PC(B,B)	PC(Y,B)	PC(B,Y)	PC(Y,Y)	S(CB)	S(CY)						
2		0.7	0.8	3	0.25	0.75	0.1	0.9	0.25	0.25					
3															
4															
5	Generation	NB(I)	NB(R)	NY(I)	NY(R)	BC(B)	YC(B)	BC(Y)	YC(Y)	N(YC)	N(BC)	NB(E)	NY(E)	L(T)	PBP
6	1	50	35	250	200	26.25	78.75	60	540	154.6875	21.5625	56.5625	354.6875	411.25	0.13753799
7	2	56.5625	39.59375	354.6875	283.75	29.6953125	89.0859375	85.125	766.125	213.802734	28.7050781	68.2988281	497.552734	565.851563	0.12070096
8	3														
9	4														
10	5														
11	6														
12	7														
13	8														
14	9														
15	10														
16	11														
17	12														
18	13														
19	14														
20	15														
21															

STEP 6 NUMBER 4

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	S(AB)	S(A _Y)	C(T)	PC(B,B)	PC(Y,B)	PC(B,Y)	PC(Y,Y)	S(CB)	S(CY)						
2		0.7	0.8	3	0.25	0.75	0.1	0.9	0.25	0.25					
3															
4															
5	Generation	NB(I)	NB(R)	NY(I)	NY(R)	BC(B)	YC(B)	BC(Y)	YC(Y)	N(YC)	N(BC)	NB(E)	NY(E)	L(T)	PBP
6	1	50	35	250	200	26.25	78.75	60	540	154.6875	21.5625	56.5625	354.6875	411.25	0.13753799
7	2	56.5625	39.59375	354.6875	283.75	29.6953125	89.0859375	85.125	766.125	213.802734	28.7050781	68.2988281	497.552734	565.851563	0.12070096
8	3	68.2988281	47.8091797	497.552734	398.042188	35.8568848	107.570654	119.412656	1074.71391	295.57114	38.8173853	86.6265649	693.613328	780.239893	0.11102555
9	4	86.6265649	60.6385955	693.613328	554.890662	45.4789466	136.43684	166.467199	1498.20479	408.660407	52.9865363	113.625132	963.551069	1077.1762	0.10548426
10	5	113.625132	79.5375922	963.551069	770.840855	59.6531942	178.959583	231.252257	2081.27031	565.057473	72.7263627	152.263955	1335.89833	1488.16228	0.10231677
11	6	152.263955	106.584768	1335.89833	1068.71866	79.9385763	239.815729	320.615599	2885.54039	781.339029	100.138544	206.723312	1850.05769	2056.781	0.10050818
12	7	206.723312	144.706319	1850.05769	1480.04615	108.529739	325.589217	444.013846	3996.12461	1080.42846	138.135896	282.842215	2560.47461	2843.31683	0.09947615
13	8	282.842215	197.98955	2560.47461	2048.37969	148.492163	445.476488	614.513907	5530.62516	1494.02541	190.751517	388.741068	3542.4051	3931.14617	0.09888746
14	9	388.741068	272.118747	3542.4051	2833.92408	204.089061	612.267182	850.177224	7651.59502	2065.96555	263.566571	535.685319	4899.88963	5435.57495	0.09855173
15	10	535.685319	374.979723	4899.88963	3919.9117	281.234792	843.704377	1175.97351	10583.7616	2856.86649	364.302076	739.281799	6776.7782	7516.06	0.09836028
16	11	739.281799	517.497259	6776.7782	5421.42256	388.122944	1164.36883	1626.42677	14637.8409	3950.55244	503.637428	1021.13469	9371.975	10393.1097	0.09825112
17	12	1021.13469	714.794281	9371.975	7497.58	536.095711	1608.28713	2249.274	20243.466	5462.93828	696.342427	1411.13671	12960.5183	14371.655	0.09818888
18	13	1411.13671	987.795696	12960.5183	10368.4146	740.846772	2222.54032	3110.52439	27994.7195	7554.31495	962.84279	1950.63849	17922.7296	19873.3681	0.09815339
19	14	1950.63849	1365.44694	17922.7296	14338.1837	1024.0852	3072.25561	4301.4551	38713.0959	10446.3379	1331.38508	2696.83202	24784.5215	27481.3535	0.09813316
20	15	2696.83202	1887.78241	24784.5215	19827.6172	1415.83681	4247.51042	5948.28517	53534.5665	14445.5192	1841.03049	3728.8129	34273.1365	38001.9494	0.09812162
21															

Step 7: Creating the simulation tab

Now that we have our simulation complete, we need to be able to visualize our data. To do this we need to add another sheet to our project.

1. Rename the current sheet.
 - a. Double click on "Sheet 1" at the bottom.
 - b. Type "Simulation" to replace the name.
2. Click on the + next to "Simulation" to add another sheet.
3. Rename Sheet 2.
 - a. Double click on "Sheet 2" at the bottom.
 - b. Type "Data" to replace the name.

Step 8: Setting up the simulation

Now let's automatically move the data to the data sheet.

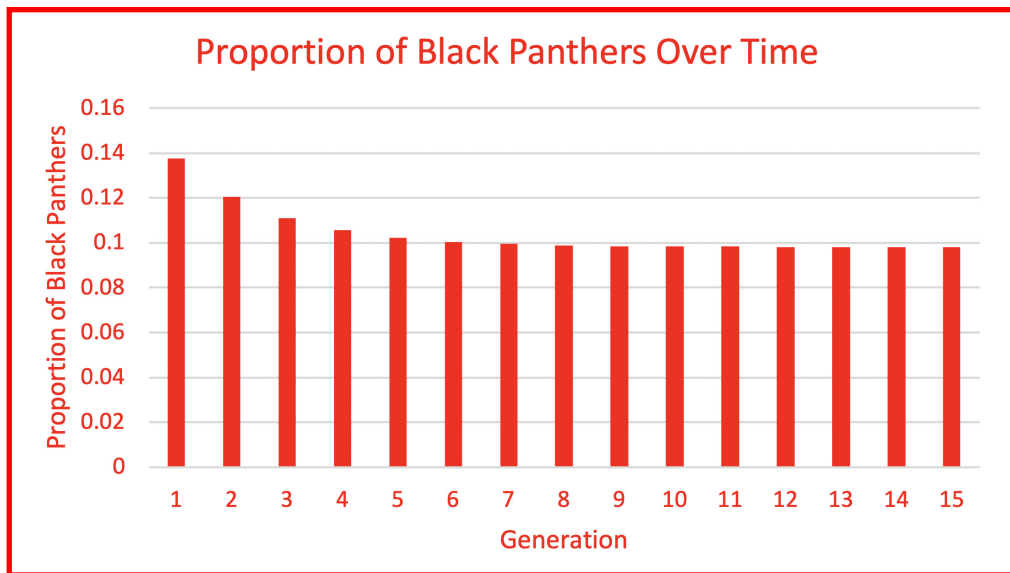
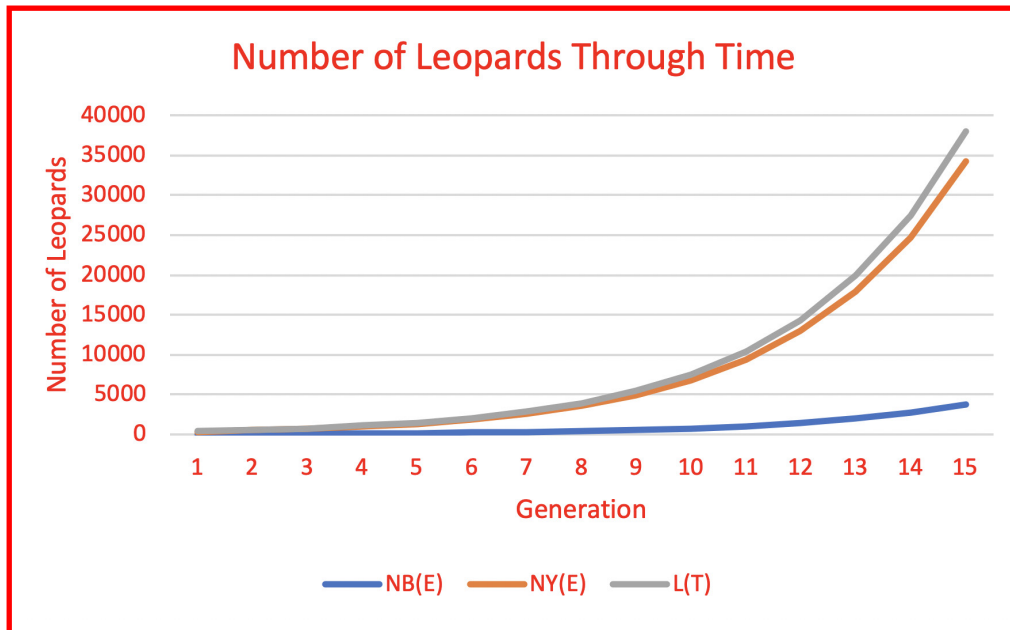
1. Click on the sheet now labeled "**Simulation.**"
2. Highlight Cells A5-A20.
3. Go to the **Edit** tab at the top and click -> **Copy** tab.
4. Click on the sheet called **Data**.
5. Put your cursor in cell A1.
6. Go to the **Edit** tab at the top and click -> Paste.
7. Click on the **Simulation** sheet.
8. Highlight cells L5 to O5 and copy them.
9. Click on the **Data** sheet.
10. Put the cursor in cell B2.
11. Go to the **Edit** tab and click -> Paste.
12. Put your cursor in cell B2 and type "=". Then click on the **Simulation** sheet and click on cell L6. This means that whatever is in Cell 6 in the **Simulation** sheet will appear in B2 in the **Data** sheet.
13. Click cell B2 in the **Data** sheet. Click and hold the black box in the lower right-hand corner, and drag the cursor down to cell B16. Release the click to fill in the column.
14. While the information in cells B2 - B16 are still highlighted, click and hold the black box in the corner and drag the cursor over to E16. Release to fill in the rest of the data table.

Step 9: Visualizing the data

Now for the graphs!

1. Click on the **Data** sheet.
2. Highlight cells B1 through D16.
3. Click on the **Insert** tab at the top of the page and highlight **Chart**, then select **Line**.
4. Click on your new line graph and move it below the data.
5. Double click on the **Chart Title** and change the title of the chart to "Number of Leopards through Time."
6. Highlight cells E1 through E16.
7. Click on the **Insert** tab at the top of the page and highlight **Chart**, then select **Column**.
8. Click on your new bar graph and move it next to the first graph you created.

Paste the graphs from the **Data** sheet here:



1. **Describe** happens to the number of black panthers and yellow leopards through time.

My graph shows the numbers of both black panthers and yellow leopards goes up through time.

2. **Describe** happens to the proportion of black panthers in the population through time.

My graph shows the proportion of black panthers decreases but then mostly levels off.

3. **Explain** the patterns you see for the number of leopards of both colors and the proportion of black panthers.

Answers should include ideas about the birth rates being high relative to the death rates showing population increase. Black panthers, however, don't survive as well as yellow leopards so their populations increasing more slowly. That means that the proportion of black panthers in the population is decreasing.

4. **Predict** what would happen if you were to run your simulation for a longer period of time. **Describe** whether you think this realistic. Support your answer.

The population would go up forever. No, this is not realistic. Eventually panthers would die more quickly or have less offspring. They can't take over and cover the entire world.

Extend the lesson: Have the students modify or explain how they would modify their spreadsheets to add more generations to test their predictions in question #4.

ACTIVITY 3: EXPLORING PATTERNS

The great thing about your spreadsheet is that you can use it to test how the system will change if you change some of your constants. Let's give it a try!

1. Click the + at the bottom of the sheet.
2. Double click on the tab labeled **Sheet 3**.
3. Rename the sheet "**Original Simulation**".
4. Click on the **Simulation** sheet.
5. Click on the small box at the far upper left above row one and to the left of column A. This will select the entire sheet.
6. Go to **Edit -> Copy**.
7. Click on the **Original Simulation** sheet.
8. Put the cursor in A1 and go to **Edit -> Paste Special**.
9. Select **Paste Formulas**.

Now your original data are saved! Save your file.

We can now do some experiments. Let's do the first one together.

Our question: Will black panthers do better if black cubs survive at a higher rate than yellow leopards?

Constant changed: S_{CB}

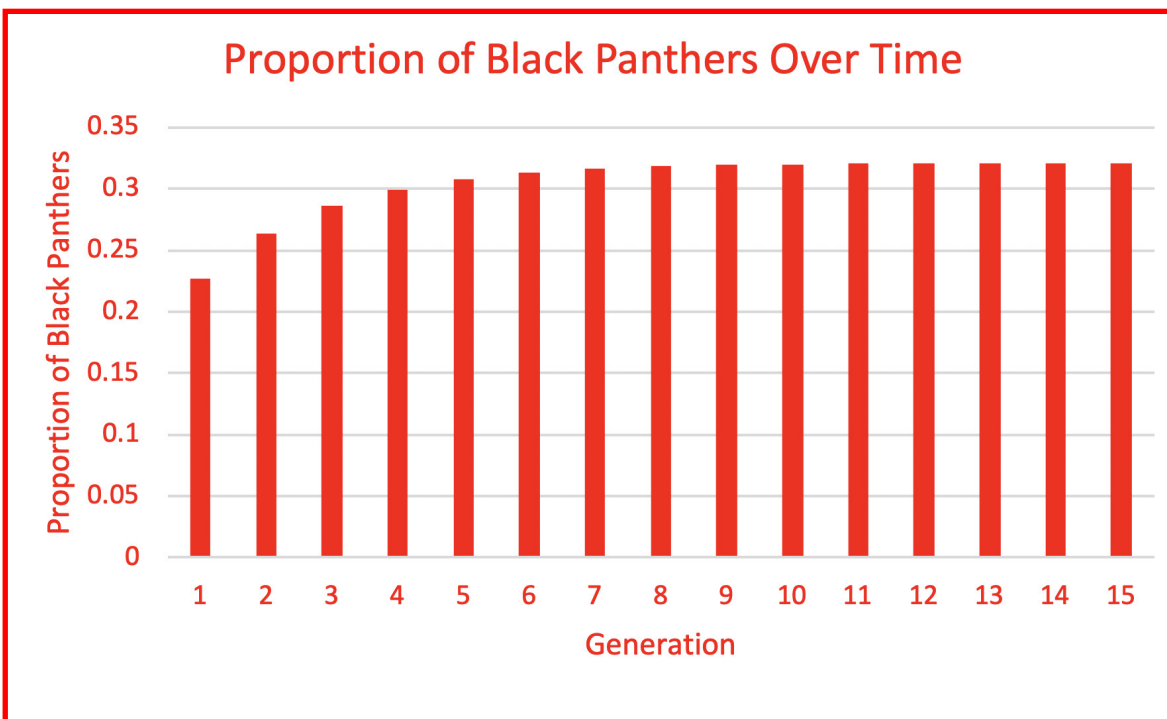
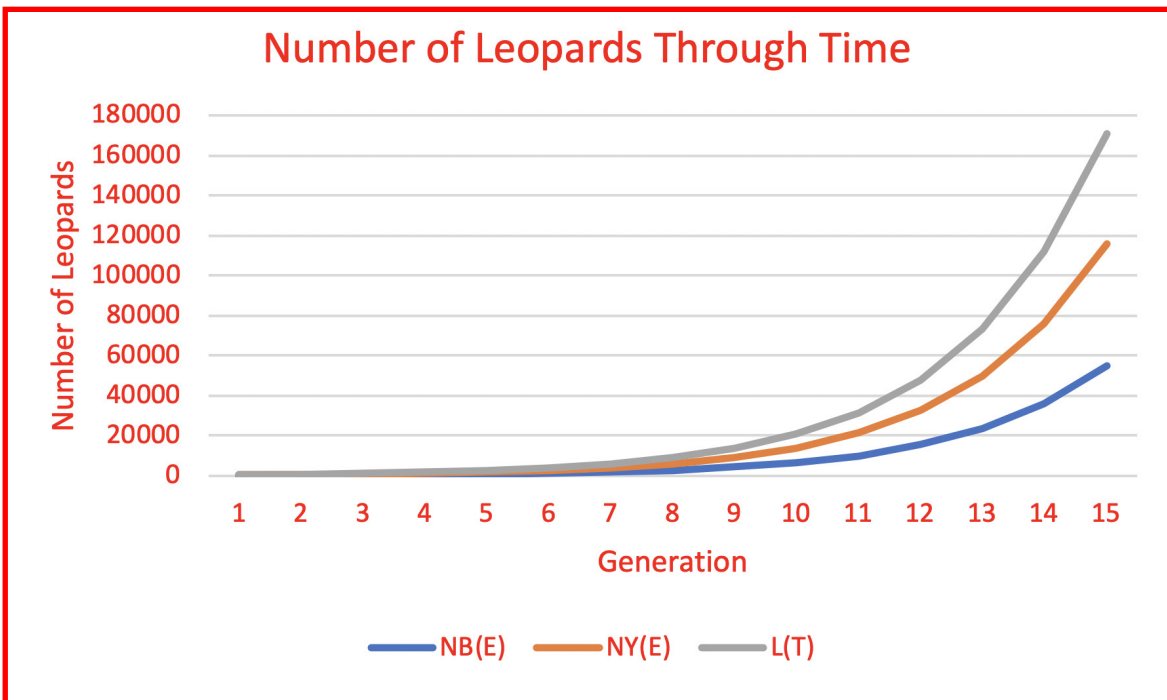
Old value: 0.25

New Value: 0.80

How to make the change:

1. Click on the **Simulations** sheet.
2. Change cell H2 from 0.25 to 0.8.
3. Click on the **Data** sheet.
4. Copy the graphs and paste them below.

Paste the new graphs from the **Data** sheet here:



1. **Describe** how greatly changing the survival rate of black cubs influenced how the total population grew. **Suggest** why you think this happened.

Students should notice that the population of leopards grew even more quickly than before. This is because more baby black panthers grew up to reproduce every year.

2. **Describe** how greatly changing the survival rate of black cubs influenced how the proportion of black panthers in the population changed through time relative to the first simulation.

The proportion of black panthers in the population increased through time until reaching about 30% of the population compared to dropping to around 9% of the population when yellow and black cubs had the same survival rate.

Now we will do one more together. Go back to your **Simulation** sheet and reset cell H2 to 0.25.

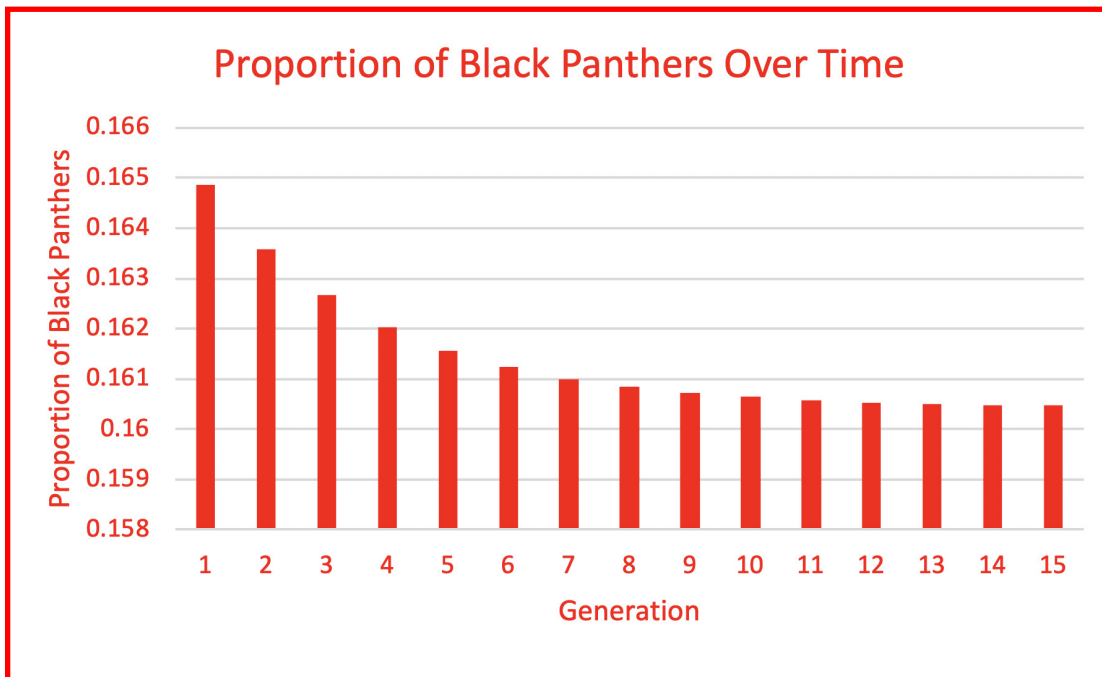
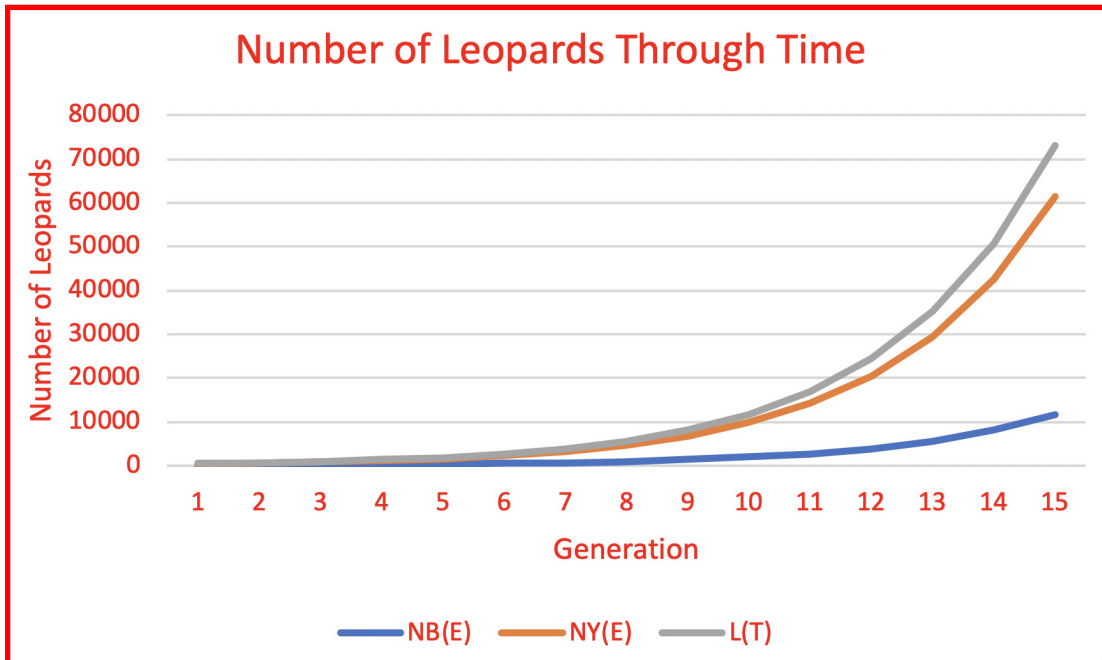
Our question: Will black panthers do better if black adults survive at a higher rate than yellow leopards?

Constant changed: S_{AB}

Old value: 0.7 New Value: 0.95

3. **Describe** the changes you made below:
 1. I clicked on the Simulations sheet.
 2. I changed cell A2 from 0.7 to 0.95.
 3. I clicked on the Data sheet.
 4. I copied the graphs and pasted them below.

Paste the new graphs from the **Data** sheet here:



4. **Describe** how greatly changing the survival rate of black panther adults influenced how the total population grew. **Suggest** why you think this happened.

Students should notice that the population of leopards grew even more quickly than before. This is because more adult black panthers survived to reproduce every year.

5. **Describe** how greatly changing the survival rate of black panther adults influenced how the proportion of black panthers in the population changed through time relative to the other simulations. **Suggest** why you think this happened. Hint: think about the genetics!

The proportion of black panthers in the population decreased through time until reaching about 16% of the population compared to dropping to around 9% of the population when yellow and black cubs had the same survival rate, or increasing to 30% when black cubs survived at a very high rate. This may happen because even though black panthers survive better than yellow leopards, yellow leopards produce far more yellow cubs than black cubs compared to black panthers that still produce many yellow cubs.

Accept answers that discuss the dominant yellow trait relative to the recessive black coat trait.

Now it is time for you to explore on your own! Start by resetting cell A2 to 0.70 on the **Simulation** sheet.

Fill in the steps below:

Our question: Answer should be a reasonable change to the program.

Constant changed: Answer should be a reasonable change to the program.

Old value: Should reflect value in original data New Value: Should be a possible number (i.e. proportion between 0-1 or rates between 0-1).

Paste the new graphs from the **Data** sheet here:

Should look similar to those above.

6. **Describe** how your change influenced how the proportion of black panthers in the population changed through time relative to the first simulation.

Accept reasonable answers that follow from graphs.

7. **Describe** how greatly changing the survival rate of black panther adults influenced how the proportion of black panthers in the population changed through time relative to the other simulations.

Accept reasonable answers that follow from graphs.