

# Watch the Birdie (Breathe)

## Concepts

- Effect of environmental temperature on the metabolic rate of endothermic animals.

## Overview

In this activity, students will develop an understanding of the effect of the environmental temperature on the metabolic rate of an endothermic animal by graphing O<sub>2</sub> consumption of birds.

## Materials

- TI-84 Plus

## Introduction

Birds and mammals are very unique critters! They are like reptiles, amphibians, and fish in a lot of ways, but they have one characteristic that sets them apart from all other animals—they are warm-blooded.

The technical word for warm-blooded is *endothermic*, which literally means “inside” (endo-) “heat” (-therm). Endotherms regulate their body heat from within and work very hard to keep their body heat at a constant temperature.

Being an endotherm has its advantages, but as with every benefit, there is a price to pay. As you look at the data in this activity, and answer the questions, be thinking about what this price is and how endotherms deal with it.

Temperature (deg. C)	O <sub>2</sub> Consumption (ml/g/hr)
-20	5.5
-16	4.8
-11	4.6
-5	3.6
0	3.4
4	3.2
10	2.7
18	1.9

## Procedure

1. Enter the data in the table on the previous page into L1 and L2 of your calculator.
  - Make sure these two lists are cleared first.
  - With your calculator on, press **[STAT]** **[ENTER]** to access the calculator's lists.
  - If there is data in either of the first 2 lists, move the cursor to the list heading, and press **[CLEAR]** **[ENTER]**.
2. Now you will graph the data in L1 and L2 so that you can graphically see if there is a noticeable relationship between the environmental temperature and the amount of oxygen a bird uses.
  - Press **[2nd]** **[Y=]** **[ENTER]**. Make sure this plot is turned On ('on' will be highlighted).
  - If this plot is "Off", move the cursor to "On," and press **[ENTER]**.
  - The rest of your screen should look like Figure 1.
3. Now the window to view a graph of the data.
  - Press the **[WINDOW]** key, and type in the settings in Figure 2.
  - When you enter a negative number, as it shows for the "Xmin", use the **[(-)]** (negative) key, which is right below the **[3]** on the calculator keypad.
4. After you have set the window, press the **[GRAPH]** key, and you should see your graph.
  - What is the independent variable (X) in this graph, temperature or oxygen consumption?
  - What is the dependent variable (Y) in this graph?
5. Draw your graph in the space below, making sure you add a title and label your axes.

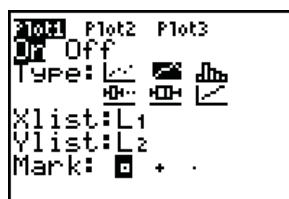


Figure 1

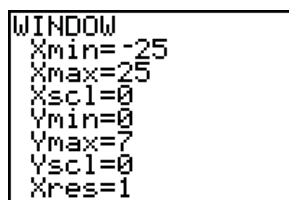


Figure 2

In order to make predictions about bird oxygen consumption at temperatures that are not in the data table, it will help to build a mathematical model for the data you already have.

6. Press **[STAT]** **[▶]** to **CALC** **[4]**.
  - You will ask the calculator to build a “linear regression” (best-fit straight line) for the data in your lists.
  - Press the following keys: **[2nd]** **[1]** **[,]** **[2nd]** **[2]** **[,]** **[VARS]** **[▶]** **[ENTER]** **[ENTER]** **[ENTER]** (Figure 3).
7. Now press **[GRAPH]**, and you will see the graph of your data with the best-fit line drawn in.
8. In the graph that you drew above, draw in the best-fit line that you see on your calculator screen.
  - With a linear regression model in place, you can now make predictions about the oxygen consumption of birds at temperatures that are not listed in the original data table.
  - One way to do this is to look at a data table of temperatures (X) and oxygen consumption (Y) that the calculator automatically produces whenever a regression line is generated.
9. Press **[2nd]** **[WINDOW]** for the Table Setup screen (Figure 4).
  - The “Tbl Start” line tells you at which value of X (in this case, the temperature in degrees Celsius) the calculator will start the data table. When you visit the Table, the y-value (oxygen consumption) will be displayed.
  - The “ $\Delta$ Tbl” stands for “delta table”, and this will tell the calculator how big an increment you want between the x-values in the data table.
  - If the “Tbl Start” is set at “0”, and the “ $\Delta$ Tbl” is set at “1”, this means that the table you will see will start with 0, then go to 1, 2, 3, etc., with each of these x-values displaying a corresponding y-value.
  - Remember that a “Tbl Start” of “0” means that you would like to see how much oxygen a bird would consume at 0 degrees Celsius. Even though this value isn’t in the original data table, starting at 0, in this case, will be just fine.
10. Now press **[2nd]** **[GRAPH]**, and you should see a table (Figure 5).
11. By using the **[▲]** and **[▼]** keys, you can scroll through the data table and view any value of X you’d like.

```
LinReg(ax+b) L1,
L2, Y1
```

Figure 3

```
TABLE SETUP
TblStart=0
ΔTbl=1
Indent:  AUTO Ask
Depend:  AUTO Ask
```

Figure 4

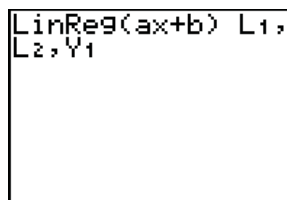
X	Y1
0	3.4878
1	3.3979
2	3.308
3	3.2181
4	3.1282
5	3.0383
6	2.9484

X=0

Figure 5

## Questions

1. What is the relationship between temperature and oxygen consumption?
  - Explain why this relationship exists.
2. What is the source of the heat that an endotherm generates?
3. The colder it gets, the more oxygen the bird uses. What process in the bird uses the oxygen that the bird inhales?
4. So, when must a bird eat more; in the summer or in the winter? Explain.
5. What are a bird's choices when the weather gets really cold?
6. Why is the oxygen consumption so low when the temperature goes up?
7. Press  $\boxed{2nd}$   $\boxed{MODE}$  (for  $\boxed{QUIT}$ ) on your calculator. This takes you back to the Home Screen.
8. Press  $\boxed{2nd}$   $\boxed{ENTER}$  until you see the Figure 6.
9. Once you see this screen, press  $\boxed{ENTER}$ , and you will see the data for the equation representing the linear regression.
10. Make note of "a" in the list, and write "a" down. This is the slope of the best-fit line.
  - Remember that slope is defined as rise/run, or the (change in Y)/(change in X).
  - What is the label that should be attached to the slope in this problem?
  - Describe what the slope means in the context of this problem.



```
LinReg(ax+b) L1,  
L2, Y1
```

**Figure 6**

Mathematical models have some limitations when you're dealing with real data. It's important to be realistic and to THINK when you are using models to make predictions.

For example, go back to the Table by pressing **[2nd]** **[GRAPH]**.

11. Press the **[▼]** until you have "25" highlighted in the "X" column.
  - What is the corresponding "Y1" value? Describe what these numbers mean.
12. Now, move the cursor down to the "X" value of 40.
  - What is the corresponding "Y1" value? Describe what this means. Is this reasonable? Why or why not?
13. If the data in the original data table is from observations of a small bird like a sparrow or a robin, predict what the data would have been if we would have used a much larger bird, like a bald eagle, for data collection.
14. Do small birds or large birds have to eat more food per gram of body mass? Explain.