Introduction to Spreadsheets

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In this course, you're going to be building many, many different spreadsheet models. We're going to be using the program Microsoft Excel, version 2007. If you do not have 2007 and have previous versions of Excel, just keep in mind that most of the things that you can do in 2007, you can also do in older versions. It's just that the interface looks a bit different. If you're using Microsoft Excel 2007 for the first time, you'll have no problem getting used to how the spreadsheet is organized. If you don't have Excel, you can use the OpenOffice version of a spreadsheet, which is called CALC, C-A-L-C, and that is freely available if you google OpenOffice.org.

The goal of this exercise is to just introduce you to the Excel interface and to also get you using many of the functions that we'll be using throughout the course. When you open up your new version of Excel or open up and launch the program itself, you'll see that three sheets are displayed. Each of these areas is called a sheet, and you can click on those to bring you to a new sheet. And if you double-click on them, you can start to type in the name of a new sheet. So let's call this 'Introduction to Excel'.

Now what you see when you open up the spreadsheet is the Office button, which is located in the upper left-hand corner, the mini toolbar, which is just to the right of that, and then you'll see what's called the ribbon. And we're going to go through each of these, in turn, just to get you oriented with how the program works.

Let's start with the **Office** button. When you click on the Office button, you'll see that there are options to open a new workbook, create a new workbook, open an existing file, save your file, save it as a different particular name, print, prepare some documentation for the file, email the file, publish it and close it.

There's also a button at the bottom labeled **Excel Options**. If you click on that, you'll see that there are many different tabs here. The first page shows you the most popular options, for example: Show the mini toolbar, Enable Live Preview, Show the Developer tab, which we'll click a little bit later, and then different types of default options. And you can change these as you'd like.

If you move to the Formulas page, you can set how the worksheet is calculated and a whole bunch of other things. Proofing is another option. You have your Save options when you press this. And then you can also have some Advanced options. Don't forget that you can use the scroll bar and make sure you can see all of the different options that you can use. For the most part, you can go ahead and keep most of these options set at the default setting. And if we're going to change anything, we'll go ahead and have you change them as we're working through a particular exercise.

There's one option that I'd like you to choose right now, though, and that is the Add-Ins page. When you click on this, this lists all of the add-ins. These are little programs that run in Microsoft Excel that are designed to do a particular thing. If you want to manage the add-ins, you go down to the very bottom and click on the button that's labeled 'Go'.

Here are the available add-ins throughout this particular course. The one add-in that you need to have is called the **Solver Add-in**, and you want to have that be selected. And then press OK, and that would add Solver up to your ribbon. And we'll cover that a little bit later, actually, in future exercises. If you don't have the option to add in the Solver Add-in, then you need to contact, or get the CDs, or contact somebody who can help you so that that particular add-in can be installed.

That is called the Microsoft Office Button. The next part that we want to cover is called the **Microsoft Office mini toolbar**. If you click on this, there's a little drop-down that says Customize Quick Access Toolbar. I call it the mini toolbar. These are the buttons that are displayed. There's the Save button. There's the Undo and Redo buttons. You can add into this mini toolbar any of the buttons that you really like and you find that you use over and over and over again.

If you really dislike the Microsoft Office 2007 version, you can actually re-create the 2003 interface using this Quick Access Toolbar and not use the ribbon at all. So we're going to add some things here a little bit later, but for now, let's just keep moving on through the program.

This section right here is called the ribbon. The ribbon contains these different tabs. There's the Home tab, the Insert tab, Page Layout tab, Formulas, Data, Review, and View. On each of these different tabs are a number of different options that you can select. The idea behind the ribbon is that commonly-used commands are grouped together. So if you click on a particular tab, like Formulas, then all of the commands that relate to formulas are found on this page.

These formulas are grouped into little boxes called 'groups'. So here's a group called the Function Library. Here's another group called Defined Names and another group called Formula Auditing.

Let's click on the **Home** tab. And the Home tab is meant to contain all of the very most frequently used commands that people use when doing spreadsheet work. These areas here - you can see here's a group called 'Alignment'. And if you see the little drop-down arrow, that means if you click on that, a dialog box will present itself which will give you more options to pursue. I'm going to push Cancel.

We're going to be using many, many different formulas and functions and these kinds of formats as possible in this exercise. If it's a bit overwhelming, don't worry. You're going to have an opportunity to create this at your own pace and your own speed. The goal of this exercise is just to acquaint you with some of the options and functions that are available within the spreadsheet.

Spreadsheets are set up in columns and rows. Columns are lettered, and rows are numbered. This box right here is the 'formula bar'. This is a place where you can enter a formula, and it tells you what cell is actively selected. I'm going to click on cell B1, and you can see the name B1 appears in the Name Box. I also know that cell B1 has been selected because the column B, and the row 1 have both been turned orange to indicate that is the active cell.

I have always felt that the best way to learn something is to just go right ahead and move right into it and learn as you go. What we're going to do in this particular exercise is we're going to set up a population of individuals that are birds. And these birds are all going to have beak sizes of a particular length. We're going to let birds with a particular beak size be survivors, and we're going to let those that don't have that particular size be killed off in some kind of an event. This is prefaced based on one of my all-time favorite books called *The Beak of the Finch* by Jonathan Weiner.

Let's start by selecting cell A4, and we're going to type the word "Individual." As you type a text reference in a particular cell, if it is larger, if the text itself is larger than the cell width, it will spill over into the neighboring cell. As you can see here, the word Individual has spilled over into column B, just a bit. If I want to change that, I can go up with my mouse, wait until the cursor changes to a crosshair, and then double-click, and that will automatically re-size my column to match the width of the text that is entered in those particular cells.

Now what we're going to do is set up a population of 25 individuals, and I'm going to show you a couple of different ways to do that. First, you can start by entering the number 1. And we're going to copy and make our population extend down to row 29 by grabbing on the right corner of that particular box until it turns into a crosshair. And then I'm using my mouse, and I'm right-clicking on that, and I'm going to drag it down. And when I release it, I have an opportunity to click Fill Series, and that will fill in a particular series of numbers through the reference that I had selected. So that's one way to do that.

A second way to do that is to simply start the series by entering the number 1 in cell A5 and the number 2 in cell A6 and then selecting both cells and then grabbing the bottom right corner and dragging this down until you find the number of individuals that you want, 25.

Just so we can see all 25 individuals, I'm going to shrink and zoom out, a little bit. And then I might want to re-size my column again. Again, by double-clicking on the right edge of that column heading.

The third way you can do this - and this is the way I'm going to set it up right now - is to use a formula. And in this case, we want to just add the number 1 to the previous cell. And so this is the simplest kind of formula. We select cell A6, and we can just begin by just typing "=" and then I can use my mouse to select cell A1 and then add the number 1 to it. And that is my formula. It's reflected up in the formula bar, and this is where I can edit that formula.

If I press the Enter key, then the entry will stick. If I've made a mistake and want to start all over, I can simply press the Cancel button. I'm going to go ahead and press the Enter button, and you'll see - that the formula - that this cell doesn't have an entry now. Instead, it is displaying the results of this particular formula.

Now what does this formula mean? This formula means what I want to appear in cell A6 is whatever value is in cell A5, and I'm going to add the number 1 to it. So if I make the number in cell A5 - be 7, then cell A6 is automatically updated.

We're going to start our individuals with the number 1 and drag them down. If I want to fill out to 25 individuals, I can simply take this cell and copy it. And I'm going to go ahead and use the commands on the Home Clipboard just so you get used to that. So here's the Copy command button. And I'm going to select cell A7, and I'm going to paste it. And when you click Paste, there are usually several different options. And throughout the course, you're going to be using different options, but for this particular case, we just need to paste that value in.

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Now these little squiggle lines here are affectionately called marching ants. And if you are bothered by them, you can simply hit the Escape key, and that will send them off on their way.

Now let's click on cell A7. And what is the formula there? I took the value in cell A6, which had this formula, A5+1, and I copied it into cell A7. But now the formula has automatically changed to A6+1. And this is what's known as a 'relative reference'. And this is something that we'll have to really pay close attention to in any kind of spreadsheet model that you do. So what that means is when I clicked on cell A6, and I entered "Is equal to A5+1," what I really was entering is 'Take the cell directly above it and add the number 1 to it.' And when I copied that formula down, now in cell A7, the formula still reads,'Take the cell directly above it and add the number 1 to it.' So that's how you know whether a reference is relative or not. It's not really referring to a particular cell. It's referring to the relative position around that cell that's used in the formula.

Now I can take that formula, go to the bottom where it turns into a crosshair. This is called the 'Fill Handle'. And I can pull this down to cell A29 and have my 25 individuals displayed.

Now that I have my 25 individuals, let's give each of those individuals a beak size. So click on cell B4 and enter the words 'Beak Size.' And, again, if you want to auto-size that, go to the top, select column B, go to the right side and double-click.

And here, we're going to create a list of beak sizes for each and every individual in our population. And we're going to use a random number to do this. The random number is one of the very simplest functions that you can use in this spreadsheet, and we'll use this a lot throughout the course.

Now to enter a function, you'd go up to the function - the **Insert Function** command. And when you click on that, it brings up a dialog box, and there are lots of ways that you can find a particular function. And, in fact, there are lots and lots of different functions that you can use. We're really only going to be using some of the most common ones for this class.

Here, if you know what you want to do, but you don't know the name of the function, you can type a brief description, and Excel will try to find something that might match or meet your needs. You can select a category of functions. This is selected the Most Recently Used. If you choose the drop-down box, and you know you want to use, say, a Financial formula, or a Date & Time formula, or a Math & Trig formula, you can find those, and then Excel will display those formulas of those types in the box below. Right now, the Most Recently Used formulas are

selected, and so this is displaying some of the formulas that I have used in the most recent cases when doing spreadsheets. Your list might look different than mine, and that's fine.

So let's go ahead and try, first, typing in "random number" because that's what we want. We want Excel to find a random number and then press Go. And it gives us several different options here, and the one that we want is just "random number." If you click on these, you'll see that Excel tells you what that particular function does. When we click on R-A-N-D, it returns a random number greater than or equal to zero and less than one, evenly distributed, and it changes on re-calculation. That's the formula that we want, so we press OK. In this particular formula, it says, "This function takes no arguments." And I'll explain that in just a couple of minutes. We'll use a different kind of formula that does contain arguments. This is all that that formula does.

Every formula begins with the name of the formula, and then two parentheses. And inside those parentheses are what are called arguments, things that feed into the formula that produce a result. In this particular case, there are no arguments, and so all we need to do is press OK, and Excel generates a random number between zero and one.

Now let's take a look at what the formatting is of this particular number. Up in my Home tab, I can see that this particular cell has a General format. And if I wanted to change how that particular format is displayed - and let's say I only want to do display two decimals - I can click on the Decrease Decimal command and show only two decimal points. Let's click on that again. And what is done is it's changed that to a number format.

Now if I want to copy this formula down, I just select cell B5, go to the bottom right corner of that, find the Fill Handle, where it changes to a crosshair, click on that, and drag and hold the mouse key down, and pull that formula all the way down through my 25 individuals. And now each of my individuals has a beak size; granted, these are pretty small birds. And so what we might want to do is change this random number and multiply that by 10. And so now I'm going to be editing this particular formula.

Let me do that again. I click on the cell, and then I go up into the formula bar, and I click on it. And now I'm in edit mode, and I can just enter the Times key and add the number 10. And now my formula says, "Equals a random number times 10," press the Enter button, and now I have a beak size. And now I can copy this all the way down through the remaining 25 individuals of the population.

Now let me tell you a quick trick for how to copy an equation or formula down through a series. Now that I've entered my formula in cell B5, I can go to the Fill handle, and instead of dragging it down, I can simply double-click rapidly, and it will automatically fill it down until the last cell in which there is an entry. So let's go ahead and do that. Okay? That makes it a lot easier for you to fill in numbers down a column, especially when you have a lot of numbers to deal with.

Okay, now you have 25 individuals and they each have a beak size. And your formula should read random number x 10, RAND()*10. And we'll double-click that all the way through and that gives us beak sizes between 0 and 10. And now the next step is to assign a sex to each one of these different individuals. So lets go ahead in cell C4 and enter the word Sex. And what we will do before we enter a formula down here is we'll create a little space spreadsheet that is set up for some inputs. So in cell F1, lets type the word Inputs, and these inputs are going to stretch across cells F1 and G1. So select those with your mouse and then go up to the Merge and Center command, and then go ahead and make that bold.

So our first input here is going to be a sex ratio, and so we'll enter the word Sex Ratio. And that's the ratio of males to females. And remember we can stretch this column over a bit by dragging the corner of the column itself. And this will be an input that we'll start with. And so by convention we will shade our inputs with the color green. So choose a color green as well as a border – green for go into the model. And lets start with a sex ratio of 0.5. So that the ratio of males to females is 0.5.

So now given this information we can enter a formula in cell C5 that will reference this sex ratio. And it will assign – it will use a random number and if that random number is less than the value here, we'll let that value be a male and if it's greater we'll let that individual be a female.

Okay? So the formula is going to be an IF function. And we can reference this by clicking on the **Insert Function** command. And then finding the IF - and this is a very common formula, IF. And if you don't know where to find it you can enter that again in the search for function. You can also do it alphabetically, if you choose All, and list them and start typing IF and it will drop you right down to the IF function.

Now this IF function has three arguments. And the first argument is called the 'Logical Test'. And so we need to state something that can be logically evaluated as true or false. So lets go ahead and make our logical test be, 'Is a random number less than the value in cell G2, rand()<G2. So that is our logical test. The random number is less than G2, and we need to anchor that G2 by pressing the F4 key on a Windows based machine. So that's our logical test.

Is a random number less than the value in cell G2? If it is, than lets record that that is a male. So the value if this is true, we will enter an 'M' for male. And if it's not – if that same random number is greater than the value in the cell G2, we're going to let that be a female. And we'll enter that with a capital 'F'. Now these need to be in quotes, because they are not numbers, they are characters and so they need to be represented in quotation marks.

So this random number is volatile, meaning it changes every time you press the F9 key or recalculate key. So in this particular formula we don't know what the actual random number is, we are telling Excel to draw a random number between zero and one, and then perform this logical test. After it performs a logical test - then if that logical test is true, the capital M is returned and if false a capital F is returned.

And when we are finished with this, we just press OK. And we can see that the first individual is a male. And again we can use this double-click trick in the corner of the box here, and click all the way through to assign a sex to each of our individuals.

Okay, now notice that the beak size in this example is not tied to the sex of an animal. And in some cases we know that males and females have different body sizes, and so you may want to some how link these two cells together. However, we're going to just assign a random sex to each individual.

In column D we're going to indicate whether these individuals survived or not. And so what we will do here, in cell D4, is enter the word 'Survive'. And we're going to let the number 1 indicate that an animal has survived a draught and we'll let a 0 indicate that the animal has not survived a draught. And this scenario is based off of one of my all time favorite books called, 'The Beak of the Finch', by Johnathan Weiner - and if you haven't read it, it's a great read. And so it's the story of one of Darwin's finches and the factors that affect their evolution.

So up here in the inputs, in cell F3, lets choose through natural selection. We're going to let animals that have a greater beak size that is greater than some value - which we will enter into cell G3 - we'll let those animals survive. So this will be a model input. So lets go ahead and shade that green and give it a border. And lets, just for the sake of a scenario, lets choose animals that have a beak size greater than 5, as animals that will actually survive.

So now, we need to enter an equation in cell D5 that will look at this individuals beak size, compare it to the beak size that's given in cell G3 and return the number 1 if it survives and the number 0 if it does not survive.

What formula would you use?

Right, it's going to be another IF function. So lets go back up and choose the insert function and find the IF function once again. And this time our logical test is going to be - we're dealing right now - we're going to enter the equation for individual one. So is this individuals beak size greater than the value in cell G3. And we need to anchor that G3 because we're always going to be referencing that cell as part of our logical test.

So we're choosing animals that have beaks greater than 5 units. And so if that number is true we'll let them survive. And we will indicate that with a number 1 and if that number is false we'll enter a 0, because that animal has died. And when we're finished we'll press the OK button. And then we can just copy this formula all the way down or double-click and the formula will be filled down for us.

Now let's take one more step back, and we're going to look at the formula again in cell D5. And what we're referencing here is cell G3. And oftentimes - one thing that Tony [Starfield] will stress throughout the course - is that it's helpful to think of equations as word equations. You know, logical thoughts and a logical stream of arguments that you want to express mathematically.

And so one way of doing that and aiding that process is to give cells a particular name. And if I wanted to name a cell, I can click, for example, on cell G3, and I can name that cell something like Survival Threshold, and there's a couple of ways that I can do this. The easiest way is to click on the cell, and then go over into this area, which is called the Name Box, select it, and then just start typing in the name that you'd like. So I'm going to call this Survival Threshold. And in this particular box, there cannot be any spaces between - any blank spaces. And so if you need to have a space maintained, use an underscore key. And when you're finished, press Enter. And now when I click on that cell, instead of G3 appearing up here in the Name Box, the actual name of the cell is revealed.

Now I'm going to go ahead and re-write the equation in cell D5. So I'm going to delete that, and I'm going to use an If function again, just to show you how it works. This was a function I just used. So find the If function. And my logical test is going to be the same. If Individual one's beak size is greater than cell G3 - but now, instead of G3 appearing, the actual name of the cell has appeared. Value if true is 1, Value if false is 0.

Now when a cell is named, by default, it has an absolute reference. And so if I press OK and copy that down, my formula will still be maintained. No matter how I look at it, I'm referencing the survival threshold value.

Now the very, very nice thing about spreadsheets is as you change these inputs, your spreadsheet will automatically be updated. So, for example, if I decided that I wanted to have a population of all males, I can enter the number 1 in cell G2, and all of the individuals will be males. If I wanted to have a population of all females, I can enter the number 0 there, and my spreadsheet's automatically updated. If I wanted to change my survival criteria or my survival threshold, I can simply change that number, and all of these formulas are automatically updated. And that is why spreadsheets are a good modeling tool.

Let's go ahead and change these back to 5 and a sex ratio of .6.

Another really handy thing to do, especially when you're spreadsheet modeling, or actually when you're just looking at data, in general, is to select some cells and apply some conditional formatting. And that will help us to really see, quickly, which species or which individuals are going to survive and which will die. And we can do that by selecting those cells and then going to the Home tab, and then going over and selecting the **Conditional Formatting** button.

Okay, if you click on the drop-down arrow, you'll see several different options.   And we're going to use this one called **Highlight Cell Rules**. But there are other options as well, and one I wanted to just point out to you is this one called **Data Bars**. And if you move over and choose one of those, and now look at column B, you'll see that those cells are shaded relative to their values from one another. So the bird with the largest beak has the largest-scale shading, and the birds with the smallest beaks are shaded hardly at all. This is a quick way for you to get a good handle, a good visual representation of the data itself.

As much as I like this option in Excel, we're going to use a different kind of conditional formatting. And we're going to select those cells and then go up to the Conditional Formatting tab and then highlight **Cell Rules**. And we're going to invoke a new cell rule, and we're going to say, "If cells are greater than," and a dialog box appears, and instead of entering a number here, we're going to collapse this dialog box and go and choose the survival threshold in cell G3, expand the dialog box, and then choose what color you want to highlight them with. Okay. This, by default, is light-red fill with dark-red text, but there are many other options you can choose from as well.

So now we have - well, we actually have both of these things invoked. We have cells and animals that have beak sizes greater than the threshold are shaded as a red. And, as we expect, those animals will survive. And we also have our formatting that tells the indication of how big or how large the numbers are, and set up as a conditional formatting as well.

I'm going to go ahead and take that one off. To do that, I'm going down to **Manage Rules**, and if I click on that, I can see I have two rules here that have been applied. The first one, if the cell value is greater than the cell in G3, here's the formatting that is applied. And then we applied the Data Bar Rule. And in this particular case, we want to delete that one. And so we click on that particular option, and then go up to the Delete Rule button and delete it, and then press OK.

Another kind of formatting that is handy is the ability to format a group of cells as a table. And this is another way of cleaning up your entries. And what we're going to do is select all of our data now, from cell A4 all the way down to D29. And we're going to click on the Home tab, and then head over toward the right-hand side and find, in the styles group, **Format as Table**. And if we click on that, you'll see a whole bunch of different styles pop up. And what these will do - choosing one of these options will automatically format your data with a nice heading and center and add some lines between the data itself.

So go ahead and choose an option. I'm going to choose this blue option here. It says, "Where is the data for the table" - is already entered because I had selected the data with my mouse beforehand. And I want to indicate that my table has headers, which are individual beak size, sex and survive. Click OK, and that formatting is automatically applied.

What's often done is you want to summarize your data and create some statistics about it. And in other words gather some outputs, some output values, as a way for you to talk about the results of your particular model. And, yes, this is a model. This is a model that shows how populations would change over time, who's going to live and who's going to die, based on these entries that we have made in the input boxes here.

And so now, what would be nice to do is to go ahead and have a section for outputs. In cell I1, let's type the word "Outputs." And let's start off by doing some very simple kinds of calculations using some formulas and functions in Excel that are very, very commonly used.

Let's start off by counting the number of males. And so we'll enter that in cell I2. And I want to go ahead and make this column auto-sized, and I do that by double-clicking on it. And let's go ahead, also, and count the number of females. And, again, I can double-click it to auto-size that.

These are my outputs, and I'm going to calculate them. I'm going to enter a formula in cells J2 and J3. And what we're going to do is shade those a different color. I'm going to choose a blue, and that would indicate that those are model outputs. These are things that would be calculated automatically for us as we change these input values.

One of the most common functions we can use is called the "Count If" function. And what we want to do in cell J2 is enter an equation that's going to count how many of these individuals are males. So let's find the Count If function. I'm going to go to the Insert Function dialog box. And if I don't know where to find this, but I know the name of the function - once again, choose All, and then type in the first letter of the function name 'C'. That'll drop you down to all the functions that begin with the letter C. And then scroll down until you find Count If. There it is. It counts the number of cells within a range that meet the given condition. We click OK, and the dialog box appears.

And this particular function has two arguments. The first thing we need to tell the spreadsheet is, "Well, what is the range of cells we want to evaluate"? And we're going to use our mouse and select cells C5 through C29.

Now what you'll notice here is that when we created this table, Excel took this column and called it Table 1, and it labeled the column here in brackets. And that's fine. That does the job that we need it to do. And our criteria is we want to count the number of males, and those are cells that have the letter 'M' in them. And the result is given, and you click OK. And that is a model output.

Now, remember, I still have random numbers here. So my beak sizes are always changing. So if I press F9, my outputs will change because I'm gathering a brand new population of birds, assigning them a sex, male or female, and then letting them live or die, according to the survival threshold.

See if you can enter a formula in cell J3 and count the number of females.

We're going to use the Insert function. In this case, I can choose the Most Recently Used category because I just used that "Count if" function, and I click OK. And my range, again, is going to be the same. And the criteria this time is I want to count those cells that have the letter 'F' in them. And notice that this is not case sensitive. It's still counting the number of females, even though they're entered in the actual data table itself as an upper-cased F.

Some more outputs that we might want to consider is getting a handle on what the range of beak sizes are in the population. So we're going to use two common functions 'Min and Max'. Enter those words in cells I4 and I5. And then in cell J4, we're going to enter an equation that tells us the minimum beak size. And that's just the function M-I-N.

We can find that, again, by going in - if we don't know what it's called, we can just type in a brief description, Minimum, click Go, and Excel pops up things that might be of interest to you. And you can click on them until you find the one you want.

And this particular function has an argument. You can enter these numbers one at a time, numbers 1, 2, 3, all the way through 25. Or, instead, just enter all of the cells that you want to examine in the first argument box. So we're going to go ahead and select cells B5, the beak size, and that's all we need to do. We don't need to enter a second argument because all of the animals are contained within this particular column. And we click OK, and that reveals the minimum beak size.

The maximum's very similar, and in fact, what I can do - the maximum is just M-A-X. I can copy this formula, select the formula with my mouse and then go Copy. And then I can come down - press Enter so you don't mess up your formula there - and I can choose inside the formula box and paste that in. So it's exact same reference. And now what I can do is just change this to Max, and that provides the maximum number. Just a shortcut way - once you begin to know the names of these functions, you'll probably start to use a lot more shortcuts than using the dialog boxes themselves.

Okay. Two other common outputs are to assess the average beak size and the standard deviation of the beak size. And so we're going to do those and calculate those in cells J6 and J7. In J6, we're just going to use an Average function, which in Excel, is just called 'Average'. But let's see if we can find it a different way.

This is a statistical function. And if you click on **Statistical**, all the different kinds of statistical functions appear, and we find it as second on the list. And here, again, we just need to enter our data range, and then press OK.

The next one we want to find is **Standard Deviation**. In this case, let's go up to the Formulas tab, and then let's find statistical functions. And in this particular case, we're going to find the standard deviation, so use the scroll bar and scroll down until you find S-T-D-E-V. This

estimates the standard deviation based on the sample size. Shrink the dialog box up, select your data, expand the dialog box and press OK.

Now all of these are outputs, and so I want to shade those the same colors I've been using back in my Home tab so that it's quickly and easily - you're easily able to find what are your outputs, and what are your inputs. You might also choose to merge those cells for outputs, as we did before, with the Merge & Center button. We can make that bold. And some people like to select their particular thing and put a big, fat box around them, a thick-border box to make sure that that's offset like some kind of a control panel.

If we want to clean up our data a little bit more, we can select columns A, B, C and D, and we can center them, left-align them, right-align them, and we can change where the position of the numbers are within the particular box itself.

Let's assume you want to know what a particular individual is doing and whether that individual survived or not . Let's enter the words "Lookup individual" in cell F4, and let's let that be an entry. And let's say, for example, that you wanted to know what Individual ten's fate was. And so this is a model input, and so we're going to color it the same color green, that we had before and make it match the borders. We're going to look up Individual ten, and we're going to find out did that individual survive or not? So, basically, what we're doing is finding number ten in this particular table and then scrolling all the way over and then recording what's in cell D14 that goes with it.

We're going to use another kind of function, and this is called a **Lookup function**. And Excel has three or four different kinds of Lookup functions, and they're really handy functions for a number of modeling purposes.

In this case, we're going to use the one called **V Lookup**, where V is for vertical. And what that means is you're going to - your data are aligned vertically, and you want to look up the number ten in the first column of a data, where the number is appearing some place in the first column.

And then the second argument of that particular function is going to be, to tell Excel, "What column do you want to return the data with? Do you want to return its beak size? Do you want to return its sex? Do you want to return whether it survived or not"?

So let's see how that function works. So let's type, in cell I8, "Lookup Result." This is an output. And in cell J8, we're going to use the Lookup function, V Lookup. And let's go ahead and go up

to the Formulas tab and choose the **Lookup & Reference** option and use and find V Lookup, which is way down at the bottom.

It says here that there are four arguments, four pieces of information that that function needs in order to provide a result. The first - click in the box - is you need to tell what value to lookup. Well we're going to lookup whatever value's in cell G4.

Then the second argument is tell the spreadsheet, "Where's the table that you're going to be looking up this information in"? And this number, whatever we're looking up, needs to be in the left-most column. So we're going to choose all of this data here, Table 1. That's because we applied this formatting to these tables here.

The Column Index indicates, "What column do you want Excel to return the information"? And in this case, we want to return whether that individual survived or not. So that's column 1, 2, 3, 4. And so we'll enter the number 4 as that particular argument.

Now you'll note, if you look in these - get in the habit of reading the information on the dialog box. What this says is this lookup, V Lookup, looks for a value in the left-most column of a table and returns a value in the same row from a column you specify. By default, the table must be sorted in ascending order. And ours is, because our individuals go from numbers 1 to 25.

And what we can do here in the last argument for the **Range Lookup** - this is not bold - and so it's not a required argument. But what this particular argument does is if you need to find the exact same match, you need to enter the word "False." And so we'll do that because we want to find the exact same match.

These functions can use lookup values that are close, close enough in a particular order, and they become handy. Using the word True is handy in some instances. We may see that later on in the course.

Once you have your equation entered, just press OK, and we find that Individual ten did not survive. This is an output, and so by convention, let's go ahead and shade that the same way we've shaded our other output boxes - and there we go.

Now one thing that you will find that is very useful to do to summarize your data in a frequency graph, or frequency chart. This is just a depiction of the raw data and it's perhaps one of the best tools to summarize your data to show a reader or a viewer what you're data look like. It's a

graphical depiction. And so, we're going to use a function called "Frequency". And it's a different kind of function it's called an 'Array' function. And let's show you how that works.

To do that we're going to start by entering in cell F7, the word 'Bins'. And I like to think of bins as a bucket. And then in cell G7 lets enter the word 'Frequency'. Okay, so what we're going to do here is start - and say well what kind of buckets do I want, or bins do I want, to summarize my data as?

And so lets go ahead and start by entering the number 1 in cell F8, and then 2. Then lets go ahead and take that series, select both cells in our series and then drag the corner of the handle down until we hit the number 10. And these are our bins, or buckets. And so what we're going to do is count how many birds have a beak size that is between 0 and 1. And we're going to record that number there [Frequency column].

How many birds have a beak size that is between 1 and 2? And that would be recorded in cell G9, and so on. And so we're going from bucket to bucket, or bin to bin, and this number represents the uppermost value of that particular bin.

Now to enter a function like the frequency function, you enter it differently than just hitting the insert function key. This is called an 'Array' function. And so we're going to enter this same formula across multiple cells at once. And so you need to begin by selecting all of the cells that this formula will pertain to. So lets go ahead and do that.

Select those cells G 8 through G17. Now lets go up to our insert function key or command. And we're going to be looking for the Frequency function. So I'm going to All and then I'm going to type the letter 'F' and then scroll down until I find Frequency. So Frequency contains two arguments. The first argument is the data_array and the second is the bins_array. So we found the function, lets click OK.

And our first argument is, where are the data that you want evaluated. So lets shrink the dialog box up and then lets simply go ahead and select, in this case lets select, the beak sizes. So we're going to drag all of our column all the way down from B5 to B29. And then lets expand the dialog box once again.

The next argument says well, where are the bins or buckets that you'd like to put and summarize the data into groups or groupings - or ever how you would like to call that. So our bins array are going to be cell F8 through F17.

IMPORTANT: Now it might be very tempting for you to press this button [OK], and I wish that it wasn't there, because when you press this button 'OK' you are going to get an error. And lets go ahead and press this right now, and you'll see that this equation was only applied to the first bin. And we don't want that to happen.

So lets go back. I'm going to delete this, and lets go back, and we'll select all of them at the same time. Find our Frequency button once again. Now I'm going to choose 'Most Recently Used'. Again our data array consists of all the beak sizes. And our bins array are bins 1 through 10. And now instead of pressing OK, I want to calculate this across the entire array. So you do that by pressing CTRL SHIFT and then Enter. And then you can tell that it's an Array function because the formula has these curly brackets around them. And the entire Array function has been completed across all of the bins at the same time.

Array functions are a really handy tool. And we'll use those occasionally in the class. The most commonly used formula that we will be using is the Frequency formula.

This means that one animal had a beak size between 0 and 1. Four animals had beak sizes between 1 and 2 and so on. And, of course, you're numbers will look different than this because these numbers, these beak sizes, are all generated with random numbers.

The next thing to do is to graph this. And so lets go ahead into the Inset tab and we're going to go ahead and insert a column chart. And we can just choose the column chart to begin with. What I like to do is go ahead and select the data before I choose this option, because then the program knows already what you're talking about. So it went ahead and graphed out the bins which we don't need to depict, as well as the frequency. And so let's scootch this over a little bit, and we can eliminate the bins series of data by just clicking on that series and pressing the delete button.

Now remember when you have a chart embedded within your spreadsheet a whole new set - a part of the ribbon - is created. And, in this case, it is the section here called 'Chart Tools' and there are three tabs.

If we choose the **Layout** tab with our chart still selected we can now go and add a title, as well as some axes. So lets go ahead and add some axes. If we start with the Primary or Horizontal axis, and choose title below axis, we can label the title here, 'Beak Sizes'. And it is inserted down below. We'll click the chart once again, and now lets go ahead and add the Vertical axis. And lets go ahead and choose the Rotated Title option. And then we'll type in the word

'Frequency'. Press enter or the checkmark and Frequency is added. We don't really need to display this portion, so we can select it and delete it. And our graph looks a little bit nicer.

So that is the Frequency function. And this gives you a very nice graphical display of your raw data. And I think that these frequency graphs are perhaps one of the most under used tools that we have in science and modeling. They give you a complete description of your full range of data pictorially.

Now there are two more functions that I'd like to introduce you to. And these are functions that are used later on in the course, and those are the **And** and the **Or** operators. And if we look at those - just go to the Formulas tab, and those are called 'Logical' functions. If you click on them, there's And, and there's Or. And both of these contain arguments that are evaluated, and the answer is either true or false.

And what we're going to do now is we're going to go through a few different cases of how we let animals survive. The case that we have right now, the formula we have right now is, if the beak size is greater than the survival threshold, it survives. Otherwise, it dies.

What I'd like to do is to take a few minutes just to demonstrate how you can combine different kinds of criteria, which will end up being useful tools for you later on in the course when you're doing some different kinds of modeling. Let's see if you can wipe out the formula in cells D5 to D30. Just push the Delete key. So our frequencies won't be affected because we still have beak sizes here.

Let's change, though, how those animals survive. And let's write an equation in cell D5 that lets all the females survive. Going to be another If function. I'm going to choose the If function. And I'm going to ask - I'm entering an equation in the same row for Individual one. Is Individual one equal to a female? If yes, the female survives. If no, it's a male, and they die.

Notice, again, this funny syntax right here is because we called this a particular table, and we named it. If that bothers you, don't use that table trick that we did earlier in the exercise.

We click OK. And now we can just copy this formula down, and we have a set of survivals where every female is surviving, and every male is dying. And you can switch those if you'd prefer, as well.

Now let's try a case, though, where we want the survivors to be large animals that have a beak size of greater than 0.5, or are males. So either one of those conditions will result in a surviving animal. And so to do that, we're going to use an Or function. So let's clear out the entries in column D.

And we're going to start this - this is going to be a Nested function because we need to evaluate two things. We need an If function, and we need to have our logical test, though, contain two kinds of criteria rather than one. And, again, this is called a 'Nested' function.

So let's start off here again. We're going to use the If formula. And our logical test now is going to include another Excel formula, called the 'Or' function. And we can do that by just typing it in directly into the first argument box here.

And if you need help with that particular function, you can click inside there, and then go up to the Name box, and you'll see this is now not referencing a cell. It's referencing formulas. And you can see if your Or function appears within that particular list. If it doesn't, select More Functions, and then find Or, click OK. And now what it's done is it's inserted an Or function, which has the green parentheses on the video here.

And now I can say, If the animal - so if the animal - the beak size is greater than the threshold survival, that's one possibility. Or, now the other possibility that could happen is that the sex could equal male.

So the Or argument is going to return - it's going to look at this logical test number 1, and it's going to evaluate it. Is it true or false? Then it's going to go to logical test 2 and evaluate that, true or false. So, in our case, it's looking at animal one. It's asking, "Is its beak size greater than our threshold, or is it a male"? And in this particular example, it's a male. So it's true, but it's smaller than the threshold, and so the first argument is false.

This function checks to see whether any of the arguments are true, and it returns a true if any of them are true. And it returns a false if all of them are false. So we can press OK.

And it gives me an error. And the reason it's giving me an error is because it's not telling me I made a error in my Or function; it's because I made an error in not finishing my If function. So go ahead and press OK.

And now we want to finish off our If function. So put your cursor right on the word If and press

the FX box again. And you can see, then, that now our long Or function has been written into the logical test. And it says, "If any of these conditions are true, then it's going to survive; otherwise, it will die." And press OK. And now our formula is filled down, and we now have a condition in which either males will survive or large animals will survive.

The other function's very similar to the Or function, and that's called the 'And' function. And, as you can imagine, it's going to take a number of arguments. And every single one of those arguments must be true in order for the function to return the word True.

So let's go up to our Insert function. Again, it's going to be an If function. And let's make up a scenario now where the beak size needs to be large, and it has to be a female. If, now let's go back up and find And. There it is. And now this one, same kind of syntax, but now every single one of these must be true in order to return the word True. If any of them are false, then the formula result will be false.

So our first test is, "Is the beak size greater than the threshold"? And our second test is whether the animal is a female. Press OK. I'm going to get that error button again, and that's okay. That error's about my If. I'm going to click on If and open up the dialog box again. So now it says, "If the animal has a large beak, and it's female, then it survives; otherwise, it dies." Click OK. And it actually auto-filled that all the way down through the table itself.

So those are the And and Or functions. And they're handy tools for you to have in your model-building toolkit.

I want to show you one more kind of tool that we'll be using in spreadsheet modeling that we'll probably use quite frequently in this course, and that is using a **spreadsheet macro**. And a macro is just a simple set of instructions that the computer does, and it reads through those instructions and so that when you press a button and run a macro, it will follow those instructions faithfully and carry out a particular task. And what you are going to do, as a developer, is tell the computer what those particular tasks are.

And so what we're going to do is develop a little macro that's going to clear out these random numbers and draw a new set of random numbers and paste the values right on top of that. And so that this is a fixed population rather than a bunch of random numbers now. And that's about as simple of a macro as we can have. And I just want to show you how you go about making a very simple little macro.

Now the first thing you may want to do is go up to the Office Button and click on it. And then choose the Excel Options tab. And then under the Popular page, select the option Show Developer tab in the Ribbon, and then press OK. And that puts a new tab right here called the Developer tab.

If we click on that, you'll see that you can get into some Visual Basic Code, you can choose these buttons to record a new macro or to view your previously written macros. This is the Relative Reference button, a very handy button, which we won't be using right now but, perhaps, in the future. And then these are different ways for you to start looking at your code and things like that, which we'll do a little bit of in this course, not too much.

Now to record a new macro, you simply select this button [Record Macro], which records a macro. And give it a name. And we're going to call this macro 'GenerateBeaks'. And you can assign it a shortcut key, such as Control G, or pick any letter you'd like.

And you're going to store this macro in this particular workbook, which is fine. You have options of storing them in other workbooks and linking macros from workbook to workbook, which lets you use macros across different sheets if you would like to.

And then, finally, enter a short description. This macro will generate beak sizes for 25 birds randomly. And we click OK. And now we are recording. Every single key stroke that we make is being recorded and written into the program in Visual Basic Programming. Don't click on that button. So any key strokes, any mouse strokes, any clicks that I do, they're being recorded, faithfully, by the program until I press the Stop Recording button.

So the first thing we're going to do in this particular program is we're going to just replace this formula with the actual same formula itself. We're going to enter a random number, and we're going to multiply it by 10, and we're going to copy that formula all the way down. Okay. So I'm just doing exactly what we've always had here.

And what I want to do next is then select those cells once more, right-click, and now I can use some other kinds of shortcuts that are available. I can copy those and select those cells one more time, right-click again, and then choose the Paste Special option and paste the values in. And click OK. So what we've done, is we've generated random numbers in this particular set of cells, and then we've replaced those random numbers with a fixed value. So there's no longer a function in those cells. They're the actual number.

Now that you're done recording, you can go up to the Stop Recording button and press that. And now you have a function that will generate new random numbers. It's called a macro. And you can find that macro by clicking on the **View Macros** button or pressing the Alt and the F8 key.

This particular macro - I made an old macro called NewBeaks. This one we called GenerateBeaks. And if I click it, and I say Run, that particular program will execute the steps that we just recorded. It's going to generate a new set of random numbers.

Let me show you, if you click on the Edit, this brings up the Visual Basic Code that was used, and I'm going to want you to focus in on this portion. This is what was actually recorded. The code itself, that is written in Visual Basic, it's Visual Basic for applications because it runs within an application, in this case, Excel.

And the information that is color-coded in green, which starts with an apostrophe are called 'Comments'. And those aren't read by the program, but they're there to help you understand what this macro was. So here's where I entered the description, and this is the name of the macro. And here is that macro shortcut key. And we'll play with this in just a second.

This is the actual Visual Basic Code. The code itself begins with the word Sub, and it runs this sub-routine called GenerateBeaks. And then it ends with words End Sub. And then here are the series of mouse clicks that we used. So we started with cell B5. We entered the formula, "Equals random number times 10." We selected B5. Then we filled down to cell B28. Then we selected the range of cells, and we copied it. I actually did it twice because I didn't - so there's two lines of code there. And if you have a duplicate line, you can edit this freely by just eliminating some of the lines of text. And then we selected that again, and we pasted in those particular values and stopped.

So I'm going to go up and close this now. It's going to look like I'm closing out of the Excel program. I'm not. I'm closing out of the Visual Basic Editor. So I'm going to close it. It brings us back to our spreadsheet. And now if I use my Control G shortcut, it will run that particular macro again.

So what it's doing is creating - populating this list of cells with random numbers. And then it's replacing them with a value rather than the random number. And you can actually see - look at the formula bar - how it's actually stepping through the macro itself.

So macros are a pretty handy way - and we're going to use those a lot in this class. They're a really, really important tool for doing some different kinds of modeling.

Now there's a couple ways - if you're like me, you'll always forget what your shortcut keys are. And so there's a few ways you can quickly assign a button or a picture to run the macro for you.

So if you click on the Insert tab on the Ribbon, and we insert - let's just pick a shape. Go to the shapes thing and find a nice shape that you like and stick it some place on your page. I'm going to go ahead and put mine right there. And now if I right-click on that shape, I can assign a macro to that particular shape. And that macro we want it to run is called GenerateBeaks. Press OK. And now if I press the smiley face, that particular macro will run.

The other way you can do it, is you can actually make your spreadsheet look more like a form. And you can add a button to your mini tab up at the top here. And I'll just show you how I did that. We're going to click on the Customize Quick Access Toolbar. And we want to show more of the commands so that you can see what is actually being displayed.

What I have on my toolbar is called a Button, which is a form control. And you can find that by clicking on the All Commands button, and this will list every single kind of button that you can pop up in your mini toolbar. So if we find the Button, and there it is, it's a form control. Click that, and then choose Add, and that's how I got my Button to be located on my mini toolbar. If you like to really customize your spreadsheet, this is a good way to do that.

So after you have it over and added to your document, press OK. And the button will appear up on your mini toolbar. Now you can click it, go anywhere in your spreadsheet, and click on the button. And you can tell the button that when you click that button, it's going to run the macro GenerateBeaks, and you press OK. And you can re-size the button if you'd like, and you can also select the words and type in a new word and call it, you know, NewBeaks or whatever it is you want to do. And now when you press that, it will run that macro as well. Okay.

We'll be learning some more shortcuts and options as we go through different exercises. We've covered a lot of ground here. But the goal of this particular exercise was to demonstrate and to show you some of the most commonly used features that we'll be using throughout this course.

Remember, you can always go back and review this particular video.

And I would encourage you to develop this spreadsheet completely on your own. And I'd also strongly encourage you to go ahead and try and take some time and click around and see what different options are available to you. And to not be afraid to try out new things and explore because you'll never know what might pop up. And there are an awful lot of things that we didn't cover in this particular exercise.

Okay. That's it for now, and thanks for watching.

< 01:23:42 END >