Old problems in Biology, etc. solved with simple Mathematics: Work booklet for problem no. 1

"Simple aids for analysis and comparison of complex spore data"

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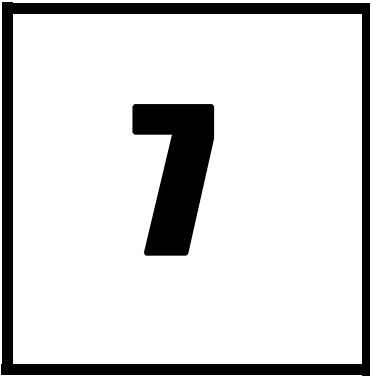
INTRODUCTION

This work booklet has been prepared for use by students as part of a presentation entitled as above.

FIRST: Be certain that all the pages in your booklet have (somewhere on the page) the same large black numeral that you see in the upper left of the present page. If this is NOT the case, advise the speaker before you go further.

NEXT, make sure this booklet includes these parts:

1. Instructions for **tasks numbered 1 through 5**.

2. **Four identical data sheets representing spore measurement data** from a real, single specimen of a species of the genus *Amanita*—a genus of mushroom distributed over nearly the entire world except for the true arctic and antarctic regions where there are no possible plant symbionts for the fungi belonging to *Amanita*.

3. A worksheet for computing and recording answers required by **Tasks no. 1 and no. 2**. Work on this worksheet will require use of <u>one of the data sheets</u>. A <u>pencil</u> and an <u>eraser</u> are required, and a <u>calculator</u> may prove useful. Part of the output of **Task no. 1** is required for doing **Task no. 5**.

4. A worksheet having the title "**Barchart**" that is intended for use in recording the results of **Task no. 3**. The Barchart worksheet contains a blank table. To carry out Task no. 3, <u>one of the four data sheets</u> and a <u>pencil</u> and an <u>eraser</u> are required. The output of **Task no. 2** will be used in the discussion of **Task no. 3**.

5. A piece of graph paper with the title "**Scatter Plot**" that is required to record the output of **Task no. 4**. Work on this worksheet will require use of one of the data sheets. A <u>pencil</u> and an <u>eraser</u> will be required for carrying out **Task no. 4**.

6. A piece of graph paper with the title "**Sporograph**" that is required to record the output of **Task no. 5**. This task can be carried out after 4 numbers are available that are generated in **Task no. 1**, namely, the 5th- and 95th percentiles of spore length and spore width measurements from the included data sheet. A <u>sharp pencil</u>, an <u>eraser</u>, and a <u>straightedge</u> will be required to carry out this task.

STOP HERE and wait for directions from the speaker.

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Note: Instructions for Task no. 1 and Task no. 2 <u>occupy two pages numbered in sequence</u>. <u>This</u> is the <u>first of the two</u> pages.

You will be placing your results for <u>both tasks</u> on the work sheet marked "**Standard Data Presentation and Data Analysis**."

INSTRUCTIONS FOR TASK NO. 1

A <u>sharp pencil,</u> and an <u>eraser</u> are required for this task, and a <u>calculator</u> may prove useful.

You will need to use one of three identical <u>data sheets</u> provided in this packet.

Scrap paper is available for you if you want to use some.

<u>Suggestion</u>: Three times in this task, you will need to compute sums of 20 decimal numbers. This is an error prone task. It is wise to have several different persons do these sums or to devise another way of checking your results.

<u>Standard Data Presentation</u> involves certain computations and the placing of the data (measured and computed) into a fixed format. The one here is preferred by Tulloss:

$$[a/b/c]\ (d–)\ e–f\ (–g) \times (h–)\ i–j\ (–k)\ \mu m,\ (\mathbf{L} = r\ \mu m;\ \mathbf{W} = s\ \mu m;\ Q = (t–)\ u–v\ (–w);\ \mathbf{Q} = y)$$

a, b, and c are fixed for your purposes because all samples consist of 20 spores measured from one specimen which (of course) can only have come from a single collection. The appropriate values are already entered on your work sheet.

<u>Describing the ranges of length, width, and Q</u>

Notice that there are <u>three ranges</u> provided in <u>Standard Data Presentation</u>—the ranges of length, width, and Q (the spore-by-spore ratio of length:width); all the ranges have identical forms:

$$(m–)\ n–o\ (–p)$$

The value for m is the lower extreme (if the 5th percentile is <u>not</u> null). The value of n is the minimum value that does not fall in the <u>5th-percentile of the data</u>. If the 5th percentile is null, n = the lower extreme; and "$(m–)$" is omitted. The o represents the <u>95th-percentile</u> of the data <u>so long as such a value exists</u>; otherwise o = the upper extreme value and "$(–p)$" is omitted. The variable p = the upper extreme value so long as it differs from a well-defined 95th-percentile value.

Example: Since 20 spores were measured to produce your data set, the data from a single spore represents 5% of the data. Here is a sample of spore lengths arranged in increasing order:

$$8.5\ 8.5\ 8.7\ 8.7\ 8.9\ 9.0\ ...\ ...\ 11.5\ 12.0$$

The minimum value occurs twice (10% of the data). Hence, there is no lower extreme. The maximum value occurs only once (5% of the data); hence, the maximum value is the upper extreme. There is a well-defined number <u>different from the maximum value</u> that is the 95th-percentile value: 11.5. Hence, the range of length is written: 8.5 – 11.5 (–12.0) µm
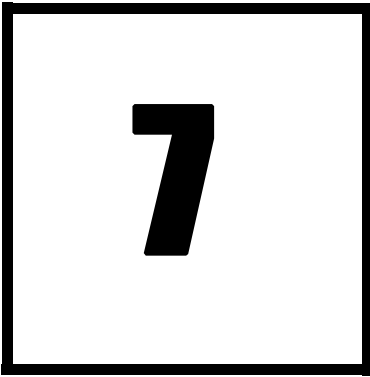
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[**Note**: Instructions for Task no. 1 and Task no. 2 occupy two pages numbered in sequence. This is the second of the two pages.]

Now, examination of your data set should allow you to fill in all three of the ranges on your work sheet.

Computation of three important sums:

Now, compute the sum of all values of length (**sum l**) and record the result.

Second, compute the sum all values of width (**sum w**) and record the result.

Third, compute the sum of all values of Q (**sum q**) and record the result.

From these values you can compute the mean length (**L**), the mean width (**W**), and the mean Q (**Q**).

Record these values on the form titled "**Standard Data Presentation and Data Analysis**" in the blank spaces provided. You will need to record the value of **L** again for Task No. 2.

Another way to check your computations

Divide **sum l** by **sum w**. Allowing for rounding and other computationally introduced errors, you should get a number very close to **Q**. For spores with low Q values, the difference between the two cited values is often 1% or less.

Qualitative terms for spore shape

Which qualitative terms of spore shape are appropriate judging by your data on the range of Q values?

You can answer this based on the following table created by Bas. Note that at the boundaries of the ranges, Bas set this system up so that two words apply to a single spore. What do you think of that approach?

qualitative term	range of Q
globose	1.0 - 1.05
subglobose	1.05 - 1.15
broadly ellipsoid	1.15 - 1.30
ellipsoid	1.30 - 1.60
elongate	1.60 - 2.0
cylindric	2.0 - 3.0
bacilliform	≥ 3.0

Fill in all appropriate terms in the fields provided on your work sheet.

INSTRUCTIONS FOR TASK NO. 2

This task is a short one. Fill in the values for mean, median, and mode of the set of lengths in your data set on your work sheet.

Check you work with your research group members.
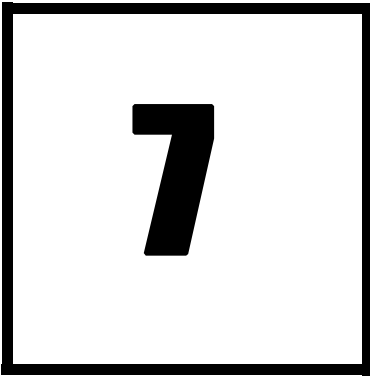
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INSTRUCTIONS FOR TASK NO. 3—"BARCHART"

A <u>sharp pencil</u>, and an <u>eraser</u> are required for this task.

You will need to use one of three identical <u>data sheets</u> provided in this packet.

You will be creating a barchart on (extraordinarily) the work sheet labeled "**Barchart**" that is included in this work booklet.

Instructions for creating the barchart

This barchart gives us a simplified view of the distribution of spore length for a specimen or a species or some other souce of spore measurement data. <u>In making the chart, we work from the top down</u>.

For the first value of length in your data set, decide to which column it belongs based on the ranges at the top of the columns. <u>Round the length you are working with to the nearest 0.5 µm</u> to find the column in which that datum belongs. <u>Working top down in each column, shade in one cell of the column for each datum that belongs in that column</u>.

Examples: A spore with length 10.3 µm belongs in the column headed by "10.5–11.5." A spore with length 10.2 µm belongs in the column headed by "9–10."

For example, if you find that you have 5 spores with lengths belonging in the column headed by the range "10.5-11.5," you should have the topmost five cells in that column shaded in.

Please, <u>shade in the cells thoroughly</u> so that other members of your research group and other research groups can see the barchart at a distance.

<u>Check your results</u> or ask a group member to check your results.
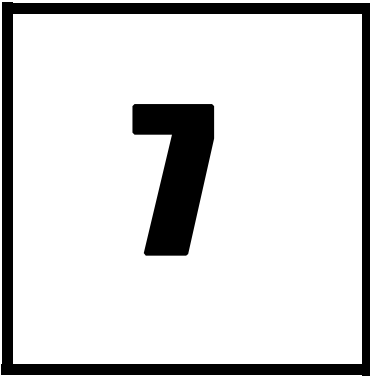
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INSTRUCTIONS FOR TASK NO. 4—"SCATTER PLOT"

A <u>sharp pencil</u> and an <u>eraser</u> are required for this task.

A <u>straightedge</u> (<u>ruler</u>) may also be useful.

You will need to use one of three identical <u>data sheets</u> provided in this packet.

You will draw your scatter plot on the <u>graph paper</u> labeled (amazingly) "**Scatter plot**."

Instructions for making the scatter plot

Each cell in the graph should be assumed to be 1 × 1 μm.

The graph paper supplied has been marked with axes. The vertical axis will represent spore length and the horizontal axis will represent spore width.

Be careful. <u>Length is presented before width</u> in your data; however, length is represented by the y-axis in this case; and width is represented by the x-axis. This has been done for a logical, but devious reason, which you will (eventually) discover.

Plot the 20 data points from the <u>data sheet</u> on the "**Scatter plot**" sheet.

<u>Make the points dark enough so that they can be seen through a sheet of paper placed on top of your plot</u>.
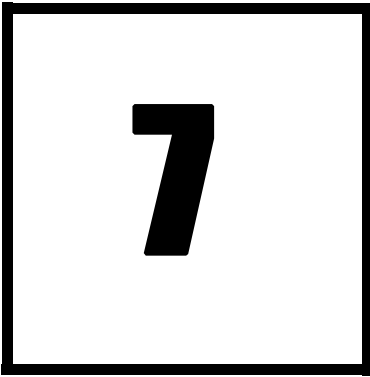
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INSTRUCTIONS FOR TASK NO. 5—"INITIAL SPOROGRAPH"

A <u>sharp pencil</u>, a <u>straightedge</u> (<u>ruler</u>), and an <u>eraser</u> are required for this task.

A <u>calculator</u> may be useful for Task no. 6 (see below).

You will <u>not</u> need to use one of the data sheets.

You will need the <u>data prepared during the performance of Task no. 1</u>. This data is on the worksheet titled "**Standard Data Presentations and Data Analysis**."

You will prepare the initial stage of a sporograph using the sheet of <u>graph paper</u> from this work booklet entitled "**Sporograph**."

Each cell in the graph should be assumed to be 1 × 1 µm.

When the initial sporograph is completed, there will be a period of discussion. After this, you will have learned how to complete the sporograph (**Task no. 6**). There is no written description of Task no. 6.

How to draw the initial sporograph

You will need the 5th-percentile and 95th-percentile values for the length data and the width data supplied with this work booklet. These four value were computed in your research group in the work on Task no. 1.

Obtain those values form the worksheet entitled "**Standard Data Presentations and Data Analysis**."

The graph paper marked "**Sporograph**" has axes already marked on it. The vertical axis will be used for plotting length values; and the horizontal axis, for plotting width values.

Remember (from the output of **Task no. 1**) that the <u>ranges of length and width</u> both have the general form

$$(m–)\ n–o\ (–p)$$

In your data the extreme values (*m* and *p*) may be missing. <u>No problem</u>, <u>we only care about the values in positions *n* and *o*</u>.

Draw (with <u>lightly drawn</u> <u>dashed</u> or <u>dotted</u> lines) the following lines:

    1. x = *n* value of the width range

    2. x = *o* value of the width range

    3. y = *n* value of the length range

    4. y = *o* value of the length range

Segments of these four lines bound a rectangle. This rectangle is your **initial sporograph**. <u>It is important that you use dashed or dotted lines</u> because the drawing will be altered when we all come to **Task no. 6**.
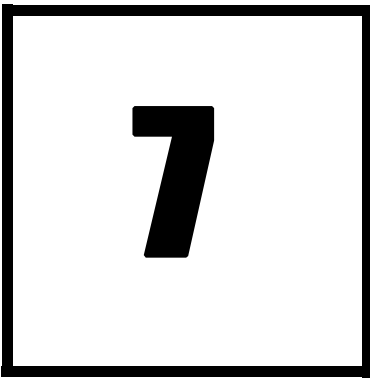
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Data Sheet - Copy 1

SPECIMEN DATA: 5.ix.1988 R. Roper & R. E. Tulloss 9-5-88-F, Benevean Dam, W of Dog Falls Park, Glen Affric, SCOTLAND, U.K. (*Amanita fulva* (Schaeff.) Fr.)

length	width	Q
9.8	9.5	1.03
9.0	8.2	1.10
11.5	11.5	1.0
11.2	10.8	1.04
11.2	10.8	1.04
10.8	9.5	1.14
10.8	10.2	1.06
11.5	11.2	1.03
11.5	11.0	1.05
11.2	10.5	1.07
11.0	10.8	1.02
10.5	10.5	1.0
10.5	10.0	1.05
10.8	10.0	1.08
10.5	10.2	1.03
11.2	10.8	1.04
11.5	11.2	1.03
12.0	12.0	1.0
11.8	11.0	1.07
14.0	13.2	1.06

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Data Sheet - Copy 2

SPECIMEN DATA: 5.ix.1988 R. Roper & R. E. Tulloss 9-5-88-F, Benevean Dam, W of Dog Falls Park, Glen Affric, SCOTLAND, U.K. (*Amanita fulva* (Schaeff.) Fr.)

length	width	Q
9.8	9.5	1.03
9.0	8.2	1.10
11.5	11.5	1.0
11.2	10.8	1.04
11.2	10.8	1.04
10.8	9.5	1.14
10.8	10.2	1.06
11.5	11.2	1.03
11.5	11.0	1.05
11.2	10.5	1.07
11.0	10.8	1.02
10.5	10.5	1.0
10.5	10.0	1.05
10.8	10.0	1.08
10.5	10.2	1.03
11.2	10.8	1.04
11.5	11.2	1.03
12.0	12.0	1.0
11.8	11.0	1.07
14.0	13.2	1.06

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Data Sheet - Copy 3

SPECIMEN DATA: 5.ix.1988 R. Roper & R. E. Tulloss 9-5-88-F, Benevean Dam, W of Dog Falls Park, Glen Affric, SCOTLAND, U.K. (*Amanita fulva* (Schaeff.) Fr.)

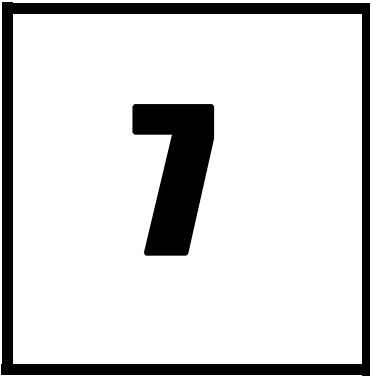| length	width	Q
9.8	9.5	1.03
9.0	8.2	1.10
11.5	11.5	1.0
11.2	10.8	1.04
11.2	10.8	1.04
10.8	9.5	1.14
10.8	10.2	1.06
11.5	11.2	1.03
11.5	11.0	1.05
11.2	10.5	1.07
11.0	10.8	1.02
10.5	10.5	1.0
10.5	10.0	1.05
10.8	10.0	1.08
10.5	10.2	1.03
11.2	10.8	1.04
11.5	11.2	1.03
12.0	12.0	1.0
11.8	11.0	1.07
14.0	13.2	1.06

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Data Sheet - Copy 4

SPECIMEN DATA: 5.ix.1988 R. Roper & R. E. Tulloss 9-5-88-F, Benevean Dam, W of Dog Falls Park, Glen Affric, SCOTLAND, U.K. (*Amanita fulva* (Schaeff.) Fr.)

length	width	Q
9.8	9.5	1.03
9.0	8.2	1.10
11.5	11.5	1.0
11.2	10.8	1.04
11.2	10.8	1.04
10.8	9.5	1.14
10.8	10.2	1.06
11.5	11.2	1.03
11.5	11.0	1.05
11.2	10.5	1.07
11.0	10.8	1.02
10.5	10.5	1.0
10.5	10.0	1.05
10.8	10.0	1.08
10.5	10.2	1.03
11.2	10.8	1.04
11.5	11.2	1.03
12.0	12.0	1.0
11.8	11.0	1.07
14.0	13.2	1.06

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"Standard Data Presentation and Data Analysis"

TASK NO. 1 RESULTS:

[20/1/1] (_____–) _____–_____ (–_____) ×

(_____–) _____–_____ (–_____) µm,

(**L** = _____ µm; **W** = _____ µm;

Q = (_____–) _____–_____ (–_____);

Q = _____), ...

Range

Qualitative adjectives for spore shape applying to at least 1 spore in data set provided:

_____

_____

Task no. 2 results:

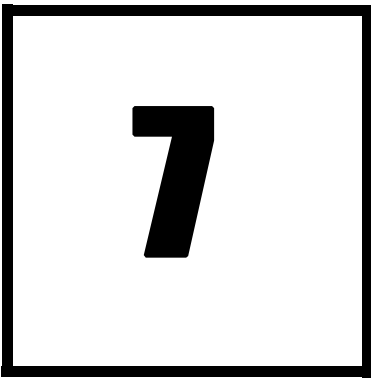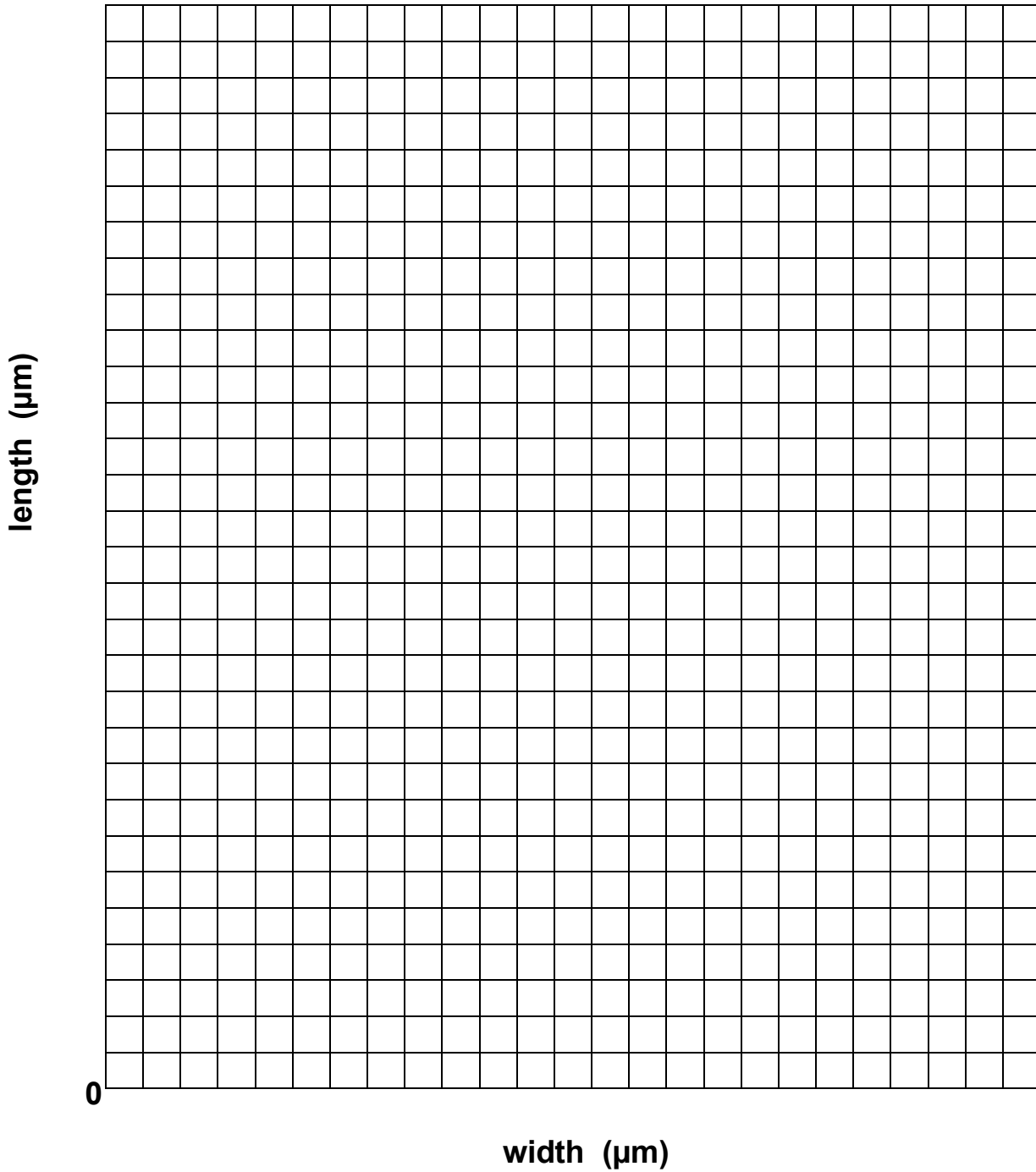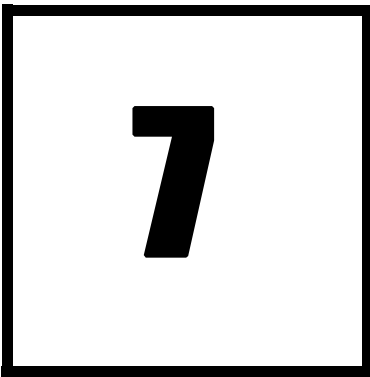mean of length data (= **L**) = _____ µm

median of length data = _____ µm

mode of length data = _____ µm

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"Barchart"

6-7	7.5-8.5	9-10	10.5-11.5	12-13	13.5-14.5	15-16	16.5-17.5

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"Scatter plot"

length (μm)

0

width (μm)

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"Sporograph"

length (µm)

0

width (µm)