

# Illustrative investigation: graph and CER

**Your goal:** Analyze supplied illustrative records and write a CER with explained limitations.

**One product:** Written CER with a dose-response claim, two specific data-point evidence entries, reasoning linking dose to worm response, and at least two limitations of the investigation.

**Question:** What does this illustrative concentration pattern support, and where does the evidence stop?

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## Start the work

Keep the original counts, scoring rule and unexpected events together so another reader can check the record.

1. Use these paper-data graphs to practice analysis related to Problem 2.3.1 Toxic Relationships.  
Graph the supplied 24-hour nonresponse counts across the five external concentration labels.
2. Make a bounded claim about the pattern in these illustrative records.
3. Cite two specific data points, including units and plate count.
4. Explain the concentration-response comparison without treating concentration as absorbed dose or proof of cause.
5. Explain at least two limitations of the supplied investigation record.

Save the same file locally. Ask the teacher for the correct Schoology assignment or course upload location.

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## Words you will use

### Illustrative record

Invented information used to practice a skill; it is not a real measurement.

### C. elegans

A small roundworm used in some biological research.

### External concentration

The amount of a substance in its surrounding mixture, not the amount inside an animal.

**ppm**

Parts per million. Here it is only the supplied mixture label; the record gives no chemical form or conversion basis.

**Dose**

The amount received by an organism. These records do not measure it.

**Condition**

One labeled comparison group in the record.

**Control**

A reference used to interpret other records.

**Plate ID**

The label for one container record, such as C0-A; no container is used today.

**Replicate**

A separately assigned experimental unit at the same condition; here each plate represents one modeled unit.

**Original count**

The 20 individuals listed at the start of each plate record.

**Found count**

The number listed as located and scored at a given time.

**Nonresponse**

The supplied scoring label N. It does not mean death or absence of all movement.

**Response**

The supplied scoring label R; it does not prove that an animal is healthy.

**Missing**

Not found in that observation. It is neither R nor N.

**Scoring rule**

The same stated way of assigning labels to every record.

**Endpoint**

The response measure at a stated time; the analysis uses 24-hour N counts.

**Time point**

A labeled moment in a record, measured here in hours from its start.

**Denominator**

The total used under a fraction; name whether it is original or found.

**Recovery count**

Here, another name for the found count. It does not mean recovery of health.

**Independent variable**

The condition varied in the modeled comparison: the external concentration label.

**Dependent variable**

The recorded response: N count at each time.

**Controlled feature**

A feature declared the same for the modeled comparison.

**Unexpected event**

A supplied observation that needs a note because it may affect interpretation.

**Baseline**

The starting reference value for a comparison.

**Scoring reference**

An all-N example used to check how labels are read; it is not a biological treatment control.

**Model assumption**

A condition declared for an example, rather than verified by actual measurement.

**Evidence**

A specific record used to support a claim.

**Limitation**

A feature that restricts what a conclusion can establish.

**Interpretation**

The meaning you give records, kept separate from their values.

**Mean**

The sum of the plate values divided by the number of plates.

**Sample standard deviation (SD)**

A measure of the spread of plate values around their mean, in the same units.

**Error bar**

A drawn interval with a named meaning; here it runs from mean minus one SD to mean plus one SD.

**n**

The number of separately modeled plate values in a summary; here n equals 2 at each concentration.

**Categorical axis**

An axis with named groups placed at equal spacing; spacing does not represent numeric distance.

**Logarithmic axis**

A numeric axis on which equal distances represent equal ratios; zero cannot be plotted on it.

**Threshold**

A boundary at which a defined effect begins or becomes detectable under stated conditions; this dataset cannot locate one.

**Claim**

A statement that answers the question within the available evidence.

**Reasoning**

An explanation of why cited evidence supports a claim.

**CER**

Claim, evidence and reasoning, followed here by at least two explained limitations.

**Correlation**

A pattern of association between values; it does not alone establish a cause.

**Causation**

A claim that a factor produced a change; it needs design and other evidence beyond this invented pattern.

**Overlap**

A region shared by two plotted intervals; it does not by itself test a difference or equivalence.

**Uncertainty**

What remains unresolved about a result or explanation.

**Peer review**

A real partner checks the stated criteria; a solo check must be labeled as your own work.

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## H1: Start with the graph

Today you will create one graph and one CER from the same supplied illustrative records. You do not need a completed prior table. The full D1 record is included again for checking.

Use the supplied paper records today. Complete one product. If the teacher assigns a different dataset, use that dataset and its directions instead; do not complete two versions.

For the first 12 minutes, use G1 and G2 only and begin your graph. A mean is a sum divided by the number of plates. SD shows spread; its bars extend 1.41 above and below each mean. Read F1 and M1 during 12-28. Read L1 during 28-48, then explain limitations at 48-60. Look up words as you reach them.

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## G1: Supplied graph values

G1 graph inputs, all invented, 24 h only. Columns: external concentration label ppm | A N count | B N count | mean N count per plate | sample SD | n. Rows: 0 | 1 | 3 | 2 | 1.41 | 2; 1 | 3 | 5 | 4 | 1.41 | 2; 10 | 8 | 10 | 9 | 1.41 | 2; 100 | 7 | 9 | 8 | 1.41 | 2; 500 | 13 | 15 | 14 | 1.41 | 2. At 24 h, every comparison plate has original 20 and found 20. These values summarize D1, including its dip from 10 to 100. S-REF is not a sixth concentration.

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## G2: Graph directions

G2 begin the graph now. Title: Illustrative 24-hour nonresponse counts. Horizontal axis: External concentration label (ppm), with categories 0, 1, 10, 100, 500 at equal spacing. This is a categorical axis, not a numeric or logarithmic scale. Vertical axis: Mean N count per plate, original and found 20; mark 0 to 20 in steps of 2. Plot means 2, 4, 9, 8, 14. Add bars of mean plus or minus 1.41. Use separate points, with no fitted curve or claim about values between categories. Caption: Invented counts; two separately modeled plates per category; bars show one sample SD. No real experiment was performed.

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## F1: Mean and spread

F1 calculation guide: mean = sum of the plate counts divided by n. Sample SD = square root of the sum of squared differences from the mean, divided by n minus 1. Square each difference before adding. For 0 ppm, mean =  $(1+3)/2 = 2$ . SD = square root of  $((1-2)^2 + (3-2)^2)/(2-1) = 1.41$  N counts. Use full precision for calculations and round graph labels to two decimal places. SD describes plate spread; it is not a confidence interval or standard error.

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## D1: Complete source records

D1 is an invented record, not an experiment you will perform. Work on paper or in a document. Do not handle organisms or chemicals. The 24-hour labels describe a fictional timeline; you do not wait 24 hours.

Use the existing table as your data table. Do not recopy it. Each row lists plate, concentration label in ppm, time in hours, original count, found count, N count, R count and missing count. N and R are supplied labels. Read them; do not carry out a response test. Missing = original minus found. R = found minus N. Check both equations without changing the source values.

D1 condition 0 ppm label. Columns: plate | time h | original | found | N | R | missing. C0-A | 0 | 20 | 20 | 0 | 20 | 0; C0-A | 6 | 20 | 20 | 1 | 19 | 0; C0-A | 24 | 20 | 20 | 1 | 19 | 0; C0-B | 0 | 20 | 20 | 1 | 19 | 0; C0-B | 6 | 20 | 20 | 2 | 18 | 0; C0-B | 24 | 20 | 20 | 3 | 17 | 0.

D1 condition 1 ppm label. Columns: plate | time h | original | found | N | R | missing. C1-A | 0 | 20 | 20 | 1 | 19 | 0; C1-A | 6 | 20 | 20 | 2 | 18 | 0; C1-A | 24 | 20 | 20 | 3 | 17 | 0; C1-B | 0 | 20 | 20 | 0 | 20 | 0; C1-B | 6 | 20 | 20 | 3 | 17 | 0; C1-B | 24 | 20 | 20 | 5 | 15 | 0.

D1 condition 10 ppm label. Columns: plate | time h | original | found | N | R | missing. C10-A | 0 | 20 | 20 | 0 | 20 | 0; C10-A | 6 | 20 | 20 | 4 | 16 | 0; C10-A | 24 | 20 | 20 | 8 | 12 | 0; C10-B | 0 | 20 | 20 | 1 | 19 | 0; C10-B | 6 | 20 | 20 | 5 | 15 | 0; C10-B | 24 | 20 | 20 | 10 | 10 | 0.

D1 condition 100 ppm label. Columns: plate | time h | original | found | N | R | missing. C100-A | 0 | 20 | 20 | 1 | 19 | 0; C100-A | 6 | 20 | 20 | 5 | 15 | 0; C100-A | 24 | 20 | 20 | 7 | 13 | 0; C100-B | 0 | 20 | 20 | 1 | 19 | 0; C100-B | 6 | 20 | 18 | 6 | 12 | 2; C100-B | 24 | 20 | 20 | 9 | 11 | 0.

D1 condition 500 ppm label. Columns: plate | time h | original | found | N | R | missing. C500-A | 0 | 20 | 20 | 0 | 20 | 0; C500-A | 6 | 20 | 20 | 8 | 12 | 0; C500-A | 24 | 20 | 20 | 13 | 7 | 0; C500-B | 0 | 20 | 20 | 1 | 19 | 0; C500-B | 6 | 20 | 20 | 9 | 11 | 0; C500-B | 24 | 20 | 20 | 15 | 5 | 0.

D1 scoring reference S-REF. Its concentration is not applicable. At each time 0, 6 and 24 hours: original 20, found 20, N 20, R 0, missing 0. This is an invented all-N label key. It is not a heat-killed preparation, instruction or evidence that an actual scoring method works.

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## C1: Reference roles

C1 reference key: C0-A and C0-B are the two no-lead-label comparison records. S-REF is a third reference record with all N labels. Keep these three roles separate. S-REF is excluded from concentration means. The no-lead records are not zero-response promises. A reference match alone cannot prove valid design, causation, death or safety.

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## E1: Retained event notes

E1 event log: at 6 h, C100-B has 18 found and two missing. At 24 h, C100-B lists 20 found, without individual tracking. Keep both entries. Never replace the earlier missing count with a later value. At 24 h, C0-A has six still labels under a look-only rule, but one N under the supplied scoring rule. Different rules yield different counts. This is a record comparison, not a request to touch an animal. Nonresponse does not establish death; response does not establish overall health.

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## L1: Read the pattern within its limits

L1 interpretation guide: observed means can be ordered even when SD bars overlap. Overlap does not test a difference or establish equality. Compare the bars for 0 and 1, then for 1 and 10: write each interval as mean minus SD to mean plus SD and decide from your own graph whether the two intervals share any region. Neither comparison is a formal significance test. The mean at 10 is 9; at 100 it is 8. Retain that dip. No response threshold or safe exposure limit follows. The first positive category already

has a different mean from zero, but no detection rule, significance test or values below 1 are supplied. Concentrations between tested labels are absent. A log axis cannot contain zero; a step from 100 to 500 has ratio five, not ten. Keep the categorical graph.

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## J1: Four review criteria

Check 1: all five means and SD bars match G1, including the dip. Check 2: two evidence points name units and n. Check 3: reasoning explains the shared rule and reference roles without proving cause. Check 4: at least two explained limits include concentration gaps and an endpoint or design gap. State a real revision or a specific reason for retaining the draft.

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## M1: A distinct library-record example

M1 is an optional invented library example. Two shelf records at each group show flagged books: Group A 2 and 4; Group B 6 and 8; Group C 4 and 6. Mean counts are 3, 7 and 5. For A,  $SD = \text{square root of } (((2-3)^2 + (4-3)^2)/(2-1)) = \text{square root of } 2 = 1.41$  books. The other groups also have SD 1.41. A categorical graph has three equally spaced groups and a vertical flagged-book count axis. Its points are 3, 7 and 5, with bars from 1.59 to 4.41, 5.59 to 8.41, and 3.59 to 6.41.

Model claim: B has the highest observed mean; the sequence is not steadily increasing. Evidence: A has mean 3 from two records, and B has mean 7 from two records. Reasoning: the same flag rule makes these counts comparable within this example. Limitations: only two records per group and no cause of the flags is supplied. A correct solo check finds the nonmonotonic C point retained. Do not copy library values into D1.

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## Try the decision

An illustrative record has an unexpected value. Decide how to use it.

- Retain the unexpected value in the illustrative record and explain its evidence limit.
- Change the unexpected value in the illustrative record to match the expected pattern.
- Call the illustrative record a real experiment and present its values as actual observations.

Explain your choice using the reading. Discuss it or say it to yourself. This practice does not add another submission.

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## Your 80-minute flow

|               |                                                                                     |
|---------------|-------------------------------------------------------------------------------------|
| 0–12 minutes  | Begin five-point graph from supplied summaries.                                     |
| 12–28 minutes | Finish graph, verify one summary and draft claim.                                   |
| 28–48 minutes | Write two numerical evidence entries and reasoning.                                 |
| 48–60 minutes | Explain at least two limits of the same CER.                                        |
| 60–72 minutes | Check graph, values, reasoning and limitations; record an actual revision decision. |
| 72–80 minutes | Save and submit the same graph/CER.                                                 |

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## Your response record

Use these labels on paper or in your document. The space below also works when this page is printed.

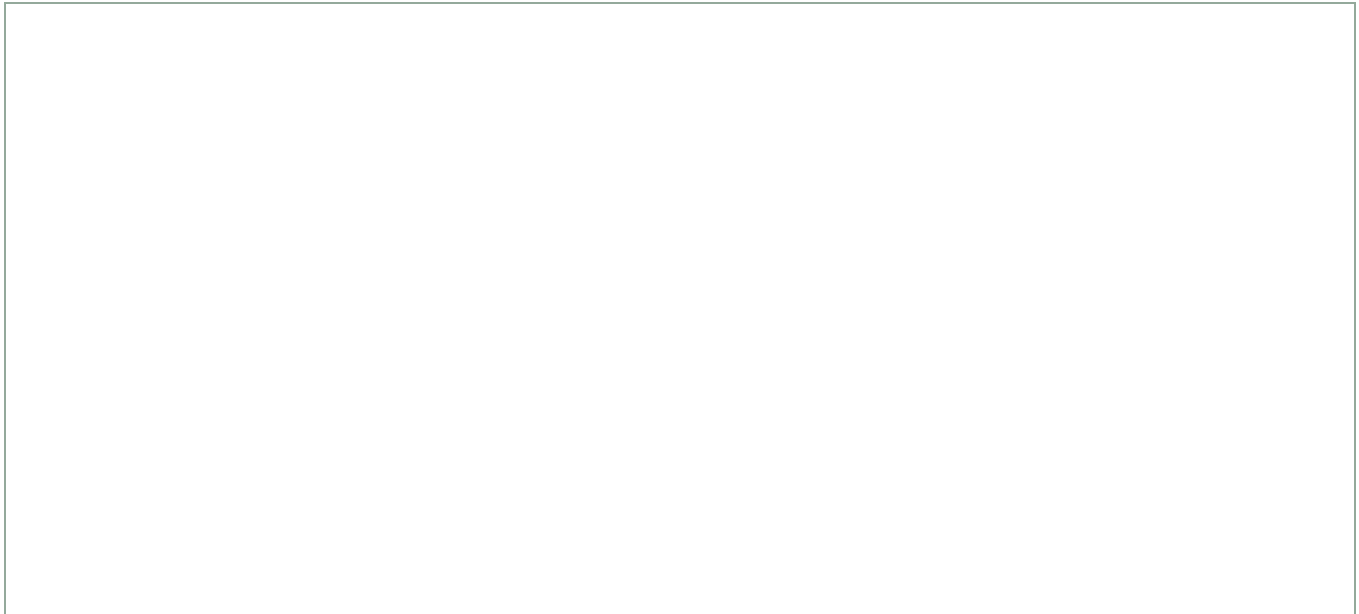
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## Begin the graph

During 0-12, use G1/G2 to draw five means and their one-SD bars. Label the title, category axis, count axis and caption.

Use the supplied summary to start. Do not calculate all summaries before drawing. Preserve the 10-to-100 dip.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.



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## Check a calculation and state a claim

During 12-28, use F1/M1 to check one condition mean and SD. Write one claim naming the tested range and irregular pattern.

One worked check suffices. Two plate values per group means  $n = 2$ , not 40 or 6. These are illustrative concentration labels, not absorbed dose.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.



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## Build one CER

During 28-48, cite two G1 data points with concentration, mean count, original/found counts and n. Explain how they support the claim.

Use the same scoring rule and 24 h endpoint. Name the two reference types and what they cannot establish. No molecular mechanism is required.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.



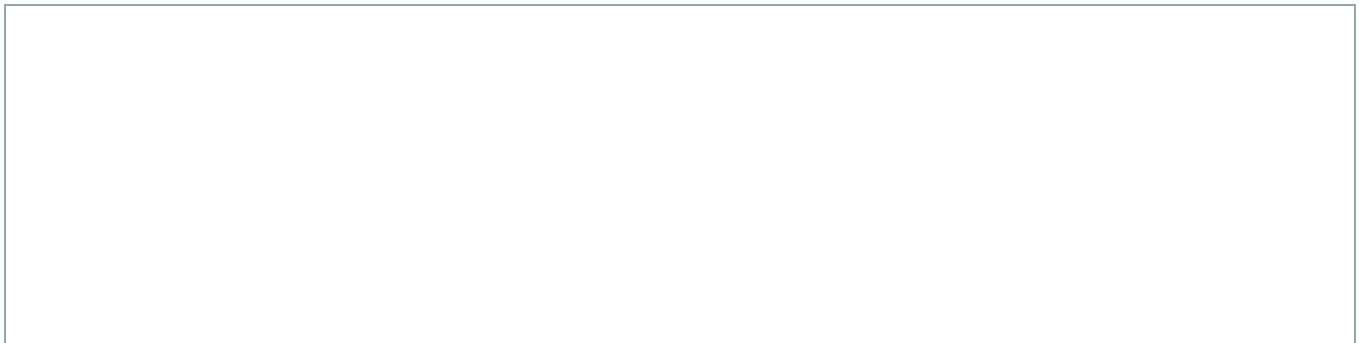
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## Explain limits

During 48-60, add at least two explained limitations using L1 and E1. Include one concentration-gap limit and one endpoint or design limit.

State why no threshold follows. One response label does not test reproduction, development or every form of harm. Do not diagnose health.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.



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## Review honestly

During 60-72, ask a partner to check the four J1 criteria, or use the same checklist yourself. Record one actual correction or a reason to keep the draft.

Label a solo check as self-review. No partner is required. Do not invent feedback.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.



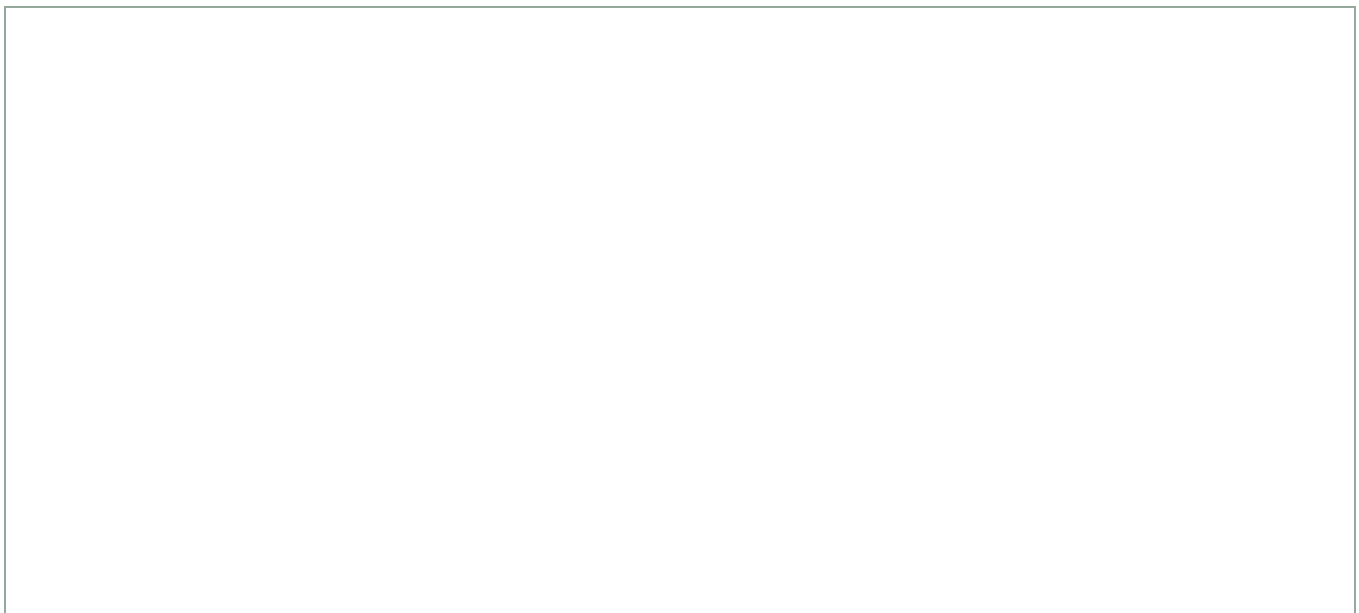
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## Revise and submit

During 72-80, revise the same graph/CER and upload it in your Schoology course.

Use the current directions and due date. If upload is unavailable, save the file and ask where it belongs. Do not submit the library model.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.



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## Check your product

- One graph and one CER use the same supplied data.
- A bounded claim, two numerical evidence entries and reasoning are present.
- At least two limitations are explained.
- A real partner check or honest self-review leads to the final revision.

**Keep the limit:** These invented counts support record checking and a bounded comparison. They cannot establish a real chemical effect, absorbed dose, death, a human health conclusion or a safe exposure threshold.

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## Turn in your work

Save your work in your Schoology course under the named assignment. Check the due date and directions there. If you cannot find or open it, save your file and ask the teacher where to upload it. After uploading, reopen the file to check that it is readable. Section 1292 uses assignment 8544589293; section 6792 uses <https://app.schoology.com/assignment/8544589319>.

Save the same file locally. Ask the teacher for the correct Schoology assignment or course upload location.

[Section 1292: Wk13 CER: Data analysis and limitations](#)

[Section 6792: Wk13 CER: Data analysis and limitations](#)

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## Carry forward

Describe the observed pattern with specific values and explain the limits that prevent a stronger claim.

Next class: examine the evidence and fairness rules used in transplant allocation. Which evidence and fairness rule could support an allocation argument?

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## Sources and resources

[Open today's page](#)

**NIST-SCALE · Measures of Scale**

NIST/SEMATECH e-Handbook of Statistical Methods

<https://www.itl.nist.gov/div898/handbook/eda/section3/eda356.htm>

**MOVEMENT-RESEARCH · Assessing behavioral toxicity with *Caenorhabditis elegans***

Anderson et al., Environmental Toxicology and Chemistry, 2004; primary research abstract

<https://pubmed.ncbi.nlm.nih.gov/15180374/>