Experimental Design For Biological Science

MSc. Students

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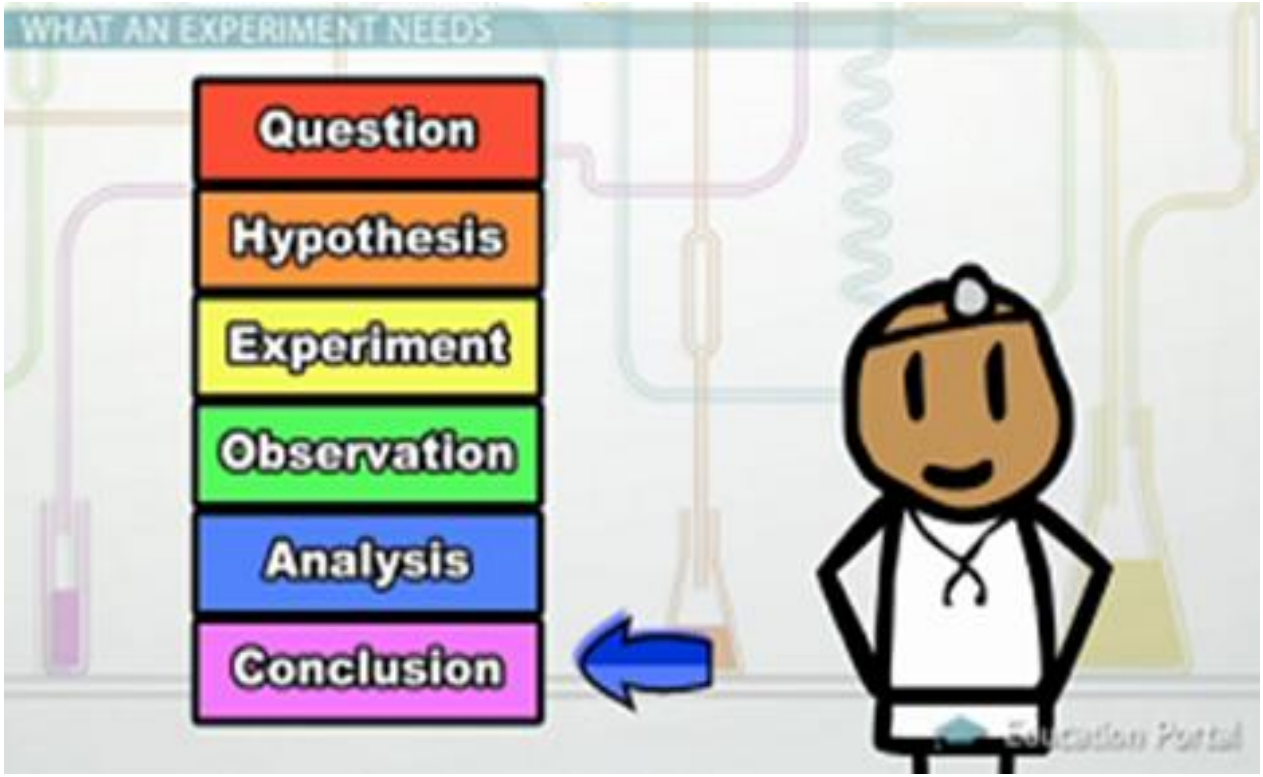
WHAT AN EXPERIMENT NEEDS
Question
Hypothesis
Experiment
Observation
Analysis
Conclusion

Question

- It is the most crucial step in scientific research. In our life there are different events, observations, conditions, etc. which draw our attention. Herein, the researcher start to ask a question?

Experiment

- Experiment is a process of study that result in the collection of data. In fact these data are not known in advance.

- Experimental Design is the process of planning a study to meet specified objectives.

Planning an experiment in proper way is a vital step in scientific research that in order to:

Ensure that the right type of data and a sufficient sample size and power are available to answer the research question(s) of interest as clearly and efficiently as possible (i.e. the objective of designed experiments is to improve the precision of the results in order to examine the research hypotheses).

Designing an Experiment

In order to design an experiment, we must:

1. **Define the problem and the questions to be addressed.**
2. **Define the population of interest.**
3. **Determine the need for sampling.**
4. **Define the experimental design.**

1- Define the problem and the questions to be addressed.

- Before data collection begins, specific questions that the researcher plans to examine must be clearly identified. In addition, a researcher should identify the sources of variability in the experimental conditions. One of the main goals of a designed experiment is to partition the effects of the sources of variability into distinct components in order to examine specific questions of interest..

- Example: Does the lemon decrease the blood pressure?

1- Define the problem and the questions to be addressed.

Three important terms we should focus on them

- Aim, Objective & Hypotheses

Aim(s): is a generalised statement about the topic you are investigating.

Example:

The aim for the previous question might be using the natural productions looks like lemon to treat some health problems.

Objectives: will describe a specific investigation where data will be included.

Example:

a- To determine the effect of lemon on the level of blood pressure

b- To investigate the effect of lemon on the smooth muscle of blood vessels.

C- To investigate the effect of lemon on the nervous system.

1- Define the problem and the questions to be addressed.

- Hypotheses (single) and Hypothesis (plural): is the formal phrasing of each objective and includes details relating to the experiment and the way in which data will be tested statistically. And it can be defined as speculation of theory and need more scientific support to be valid that will be achieved by the experiments.

- Generally we have to format two types of hypothesis for each objective:
- 1- Null Hypotheses: which refer to that there is no significant differences between the groups and denoted by H_0.
- 2- Alternative Hypothesis: states that there is statistical significance between two groups. denoted by H_1.
- Example
- H_0: There is no significant differences between the people who treat with lemon and the control group
- H_1: There is a significant difference between the groups of people.

2- Define the population of interest.

- Biological population is a collective whole of people, animals, plants, or other items that researchers collect data from.

- Statistical population is defined as the collection of all the possible observations of interest.

Before collecting any data, it is important that researchers clearly define the population, including a description of the members. The designed experiment should designate the population for which the problem will be examined. The entire population for which the researcher wants to draw conclusions will be the focus of the experiment.

3- Determine the need for sampling.

- A *sample* is one of many possible sub-sets of units that are selected from the population of interest.

An important question about sampling should be asked which is: How large should the sample be? (Representative sample) Determining the sample size requires some knowledge of the observed or expected variance among sample members in addition to how large a difference among treatments you want to be able to detect. i.e the observations recorded by this method should closely match the result that would be obtained if every item in the population was measured.

How can we obtain the representative sample?

- There are four types of sampling methods. Most of them are designed to for particular circumstances:
- *1- Random sampling*: is a sub-set of units that are selected randomly from a population. A random sample represents the general population or the conditions that are selected for the experiment because the population of interest is too large to study in its entirety.(each item must have equal chance of being sampled each time.
- *2- Systematic/periodic sampling:* This is regularised sampling methods, where an item at regular interval is chosen for observation.
- *3- Stratified random sampling:* is a combination of the above two models, where random sampling occur at regular intervals.
- *4- Homogenous stands:* this one need to be selective and identify areas for your investigation that are homogenous. (keep it as it).

4- Define the experimental design.

- Experimental design is the process of planning a study to meet specified objectives. Planning an experiment properly is very important in order to ensure that the right type of data and a sufficient sample size and power are available to answer the research questions of interest as clearly and efficiently as possible.

1. Identify the experimental unit (person. Species of animal or plant, lands).
2. Identify the types of variables (will be discussed later).
3. Define the treatment structure (factors).
4. Define the design structure (Completely Randomized Design, or Randomized Complete Block Design (will be discussed later)).

- There are two types of scientific investigations:

1. Observational investigation
2. Experimental Investigation

1- Observational studies

Here researchers observe the effect of a risk factor, diagnostic test or treatment without trying to influence what happens. Such studies are usually "retrospective" — the data are based on events that have already happened. Most workplace health research falls into this category.

- Cohort study:

For research purposes, a cohort is any group of people who are linked in some way and followed over time. Researchers observe what happens to one group that's been exposed to a particular variable — for example, the effect of company downsizing on the health of office workers. This group is then compared to a similar group that has not been exposed to the variable.

1- Observational studies

- Case control study:

Here researchers use existing records to identify people with a certain health problem (“cases”) and a similar group without the problem (“controls”). Example: To learn whether a certain drug causes birth defects, one might collect data about children with defects (cases) and about those without defects (controls). The data are compared to see whether cases are more likely than controls to have mothers who took the drug during pregnancy.

1- Observational studies

- Some strengths of observational studies

This may be the only way researchers can explore certain questions. For example, it would be unethical to design a randomized controlled trial (see below) deliberately exposing workers to a potentially harmful situation.

- But...

The results of observational studies are, by their nature, open to dispute. Example: A cohort study might find that people who meditated regularly were less prone to heart disease than those who didn't. But the link may be explained by the fact that people who meditate also exercise more and follow healthier diets.

2- Experimental studies

- Here researchers introduce an intervention and study the effects. Experimental studies are usually randomized, meaning the subjects are grouped by chance. While not all controlled studies are randomized, all randomized trials are controlled.

- Randomized Controlled Trial (RCT)

Eligible people are randomly assigned to two or more groups. One group receives the intervention (such as a new drug) while the control group receives nothing or an inactive placebo. The researchers then study what happens to people in each group. Any difference in outcomes can then be linked to the intervention.

2- Experimental studies

- **Controlled Clinical Trial (CCT)**

This is similar to an RCT, except that subjects are not randomly assigned to the treatment or control groups. This increases the chance for "bias"–that is, that people with similar qualities ended up in each of the groups which could influence the final results.

- Some strengths of experimental studies

The RCT is still considered the "gold standard" for producing reliable evidence because little is left to chance.

2- Experimental studies

- But...

There's a growing realization that such research is not perfect, and that many questions simply can't be studied using this approach. Such research is time-consuming and expensive — it may take years before results are available.

In general in an investigation studies there are two main types of designs:

1- Completely Randomized Design (CRD) is probably the simplest experimental design, in terms of data analysis and convenience. With this design, subjects are randomly assigned to treatments. Treatment. Placebo. Vaccine.

2- Randomized Complete Block Design (RCBD) The field is divided into blocks and. each block is divided into a number of units equal to the number of treatments. Within each block, the treatments are assigned at random so that a different treatment is applied to each unit.

CRD

- Example
- A fast food franchise is test marketing 3 new menu items. To find out if they the same popularity, 18 franchisee restaurants are randomly chosen for participation in the study. In accordance with the completely randomized design, 6 of the restaurants are randomly chosen to test market the first new menu item, another 6 for the second menu item, and the remaining 6 for the last menu item.

- Problem

Suppose the following table represents the sales figures of the 3 new menu items in the 18 restaurants after a week of test marketing. At .05 level of significance, test whether the mean sales volume for the 3 new menu items are all equal.

	Item1	Item2	Item3
1	22	52	16
2	42	33	24
3	44	8	19
4	52	47	18
5	45	43	34
6	37	32	39

RCBD

Example

- A fast food franchise is test marketing 3 new menu items. To find out if they have the same popularity, 6 franchisee restaurants are randomly chosen for participation in the study. In accordance with the randomized block design, each restaurant will be test marketing all 3 new menu items. Furthermore, a restaurant will test market only one menu item per week, and it takes 3 weeks to test market all menu items. The testing order of the menu items for each restaurant is randomly assigned as well.

- Problem

Suppose each row in the following table represents the sales figures of the 3 new menu in a restaurant after a week of test marketing. At .05 level of significance, test whether the mean sales volume for the 3 new menu items are all equal.

	Item1	Item2	Item3
1	31	27	24
2	31	28	31
3	45	29	46
4	21	18	48
5	42	36	46
6	32	17	40

References

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