Research Terms and Methods

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This page is meant to summarize research methods for readers who lack a scientific background. The information below will help readers evaluate the studies and trials reported throughout the site and understand the terminology used to describe them.

The National Center for Complementary and Integrative Health also has a great overview.

Pre-Clinical Research
Laboratory work is considered "Pre-Clinical" research.

- *In vitro* studies are the most basic. They involve experiments on cells or parts of cells. These experiments are simplest and cheapest. *In vitro* is Latin for "within the glass"; *in vitro* experiments are performed in test tubes or dishes.
- After seeing the results of *in vitro* studies, scientists usually verify these results with *in vivo* experiments in model organisms, like mice. *In vivo* is Latin for "within the living"; *in vivo* experiments are performed in living animals. Though they are more expensive and time-consuming than *in vitro* studies, *in vivo* experiments account for the nuances of a complex organism, made of different kinds of cells, tissues, and organs.
- In some cases, scientists may perform an experiment on cells isolated from a model organism. Since the experiment is no longer within the organism, it is called *ex vivo*. (In *in vitro* studies, the cells are not isolated from lab animals but purchased as purified 'cell lines'.)

To confirm a hypothesis or provide evidence for an effect, one *in vitro* and one *in vivo* experiement are not enough. A research group must validate its results with multiple experiments using different models before their work can be published in a journal. A publication requires years of work. In addition not all journals are equal. Peer-reviewed scientific journals are more reliable because the research they publish is scrutinized by experts in the field.

For strong evidence about a substance or technique, one publication in one journal is not enough. Different research groups at different institutions should produce similar results supporting the same conclusions. When many papers, published in different journals and authored by different groups, show that a substance or treatment may benefit humans, the substance/treatment passes the "Pre-Clinical" phase, and it can now be tested in humans.

Clinical Research
Clinical research involves humans. Clinical trials are experiments that test drugs or practices (for example, yoga) in humans. These usually take ten years or more to complete, and they are very costly.

Read more about how clinical trials are structured and how to find them.

Depending on how the information is gathered, clinical data can be more or less reliable.

- Case studies do not provide convincing evidence for a treatment or drug. They are purely observational. For example, a doctor may observe that patients who took X supplement experienced Y, and she may publish those findings. However, it is unclear whether X caused Y or some other aspect in the patients' lives (a confounding factor) caused Y. It is also unclear whether people who don't take X don't experience Y. So, the information a case/observational study provides is merely an association, or correlation. There is a well-known aphorism that **correlation does not imply causation**. Observational studies can only show correlations; they do not provide evidence for a causation. If a journal publishes a case study of forty-two patients who took mistletoe and felt more energetic, one cannot conclude that mistletoe caused them to feel more energetic.
- The alternative to observational studies are experiments. "**Controlled**" experiments involve a group of people given a drug or treatment (the treatment group) and a group of people not given the drug (the control group). After the treatment period, experimenters collect data from the two groups. If there is a difference between the two groups, and statistical tests show that the difference is significant (usually, p-value <0.05), then the experimental result provides evidence that the drug caused the difference. So, experiments *do* provide information about causation.
- An experiment provides stronger evidence if it is not only controlled but also **randomized**. This means that participants are randomly assigned to be in either the treatment or control group. Randomized controlled trials are commonly abbreviated RCTs.
- A trial can also be 'blind.' In a single-blind trial, the participants do not know whether they are in the treatment or control group. They all take a pill, but for the control group the pill contains no active ingredient. This "fake drug" is called a **placebo**. In a double-blind study, neither the researchers nor the participants know in which group the participants are.
- The more participants a clinical trial has, the more reliable it is.

So, the ideal study is large, randomized, controlled, and double-blind. Drugs tested in well-designed clinical trials are more likely to be approved by the US Food and Drug Administration (FDA).

In summary, questions that can guide an evaluation of scientific research are:

1. Is the research published in a reputable, peer-reviewed scientific journal?
2. Have the researchers supported their findings with multiple experiments?
3. Have other groups of scientists found similar results?
4. How big was the clinical trial?
5. Was the clinical trial randomized? Controlled? Double-blind?
6. Have other clinical trials verified the results?

These guidelines are basic. For more information on assessing clinical trials, see the National Cancer Institute's PDQ Levels of Evidence.