

Human Anatomy & Physiology I

Lab 3 Scientific method – What is the best predictor of lung capacity?

Learning Outcomes

- Design and run a controlled experiment that will distinguish between competing hypotheses about how to most accurately predict lung capacity.
- Graph their experimental data in such a way as to indicate whether the tested hypothesis is supported by the data.

General background Information

In lay speak, people tend to use the terms hypothesis and theory interchangeably. When most people use these terms, they mean some kind of explanation that is far from proven. They basically use both terms to describe a stab in the dark. Scientists use these two terms differently. For scientists, the two terms are at opposite ends of a continuum of evidence. A **hypothesis** is a tentative explanation that could possibly fit what little evidence is available. A **theory** is a well-tested explanation that is supported by a wealth of evidence. Scientific knowledge starts out with hypotheses and accumulates into well-established theories.

Scientific explanations, whether they are tentative hypotheses or well-supported theories, are characterized by the fact that they **make predictions** that can be tested and can be potentially falsified (proven wrong!) If an explanation doesn't make predictions that can be tested, it really isn't a scientific explanation.

Controlled experiments are a favorite way of testing hypotheses. In today's lab you will be designing and running a controlled experiment to test a hypothesis you come up with at the beginning of the lab. But while experiments are one way of testing hypotheses, you should keep in mind that they aren't the only way. Hypotheses and theories that involve very large things or very slow things often cannot be subject to experiments. Yet these are still scientific explanations if they make falsifiable predications. For instance, any kind of explanation for the movement of planets can't really be tested by running experiments on planets. But the predications made by the explanation can be tested. You *observe* the way the planets move and you determine if that movement is consistent with behavior *predicted* by the explanation. (Careful observations and measurements of Mercury's orbit were one way Newton's theory of celestial mechanics was falsified and Einstein's theory of relativity was supported.)

Also keep in mind, while it always possible to falsify a scientific hypothesis, by proving it wrong, it is never possible to truly prove a hypothesis or theory. All you can do is provide more and more evidence in support of it. At some point, the evidence becomes so overwhelming that scientists accept a theory as essentially proven. But it is always a possibility, however remote, that a new experiment, better designed than any that has preceded it, can come along and falsify even the most highly regarded scientific theory.

In today's lab you will be designing and implementing your own controlled experiment. A controlled experiment is simply one where control groups are included as part of the experimental design. **Control groups** are designed to rule out alternative explanations for the experimental results. The simplest control groups are ones in which an experiment is repeated, keeping everything identical except one thing. If a different outcome is achieved, you have strong evidence that the one thing that was different between the two trials was the cause of the change.

For instance, when in drug testing one group of volunteers is given a new drug and another is given a placebo, the placebo group serves as the control. If the group given the new drug don't do significantly better than the placebo group, we assume the drug does not work. If the group given the new drug does do significantly better, we have evidence the drug does work. Controls rule out alternative explanations. In this case, the control (placebo) group rules out the alternative explanation that the volunteers would have gotten better in the same amount of time whether they were given the drug or not.

As the controls in any experiment (and there is often more than one control group) are there to rule out alternative explanations to your hypothesis, the ideal control would be is identical to your experimental group in every way except for one. This ideal control would rule out all possible alternative explanations. But it is rarely, if ever, possible to achieve this ideal. There is almost always going to be something extra different between your control group and your experimental group. Some of these differences you might notice (using different individuals in the two groups, for instance), and some you might not even be aware of (slight variations in the ways the experiment was run between the two groups, perhaps.) Experiments are always imperfect and even positive results should be treated as tentative. Your experiment or your controls might be flawed and might be giving you misleading results. You need confirmation from other experiments and from other researchers. Science requires a lot of evidence from a lot of different experiments before any significant amount of trust is put in any explanation or hypothesis. But, if a large number of different experiments by different researchers all support a hypothesis, you can assume that each experiment had its own minor flaw but that in each case the flaws were probably different. After a while, a large body of scientific evidence for a hypothesis results in the various individual flaws canceling each other out. It becomes less and less likely that the hypothesis is wrong.

Science does not usually result in the "eureka!" moment of popular conception, in which everything is explained or understood all at once. Science proceeds in baby steps. Individual experiments almost always move knowledge forward just a tiny bit. They build on what was discovered previously and they add a small amount more. A typically experiment tells you one new thing about its subject. You need a large number of such experiments before you understand that thing completely.

Summary of Important Background Concepts

- A scientific hypothesis must always make a testable prediction.
- You can definitely falsify a hypothesis (prove it wrong) but you can never definitely prove a hypothesis.
- You can, however, eventually have so many lines of evidence supporting a hypothesis (theory) that it will be accepted as very close to definitely proven.
- Experiments are one way of testing a hypothesis's predictions.

- A controlled experiment ideally isolates one factor and determines whether it produces a predicted outcome.
- A control group is designed to rule out alternative explanations for your results.
- An ideal control group is identical to the experimental group in every way but one.
- Achieving the ideal control group is almost impossible, though we still try as hard as we can.
- One experiment usually only tells you one small new thing about its subject.

In today's lab, we are running a different kind of control than the control groups given as examples above. The control groups will be alternative hypotheses for the phenomenon we are studying. By testing different hypotheses simultaneously, we are ruling out the possibility that all our hypotheses are correct. We hope to find one hypothesis that matches our results, and to be able to discard the alternatives.

Procedure

Articulating the hypothesis

Start with observations.

- Is everybody in the world the same size?
- Will everyone in the world have the same size lungs?
- What will different sized lungs result in?

The instructor will write down the observations on the board as they are suggested.

Now suggest hypotheses about which features in a person might be the best predictor of a person's total lung capacity.

Total lung capacity is the maximum volume of air an individual can hold in their lungs. It is not the size of a typical breath (that is known as the *vital* lung capacity); it is all the air the lungs hold when the individual has taken the largest breath they can. It is also equivalent to the total volume of air exhaled after filling up the lungs and exhaling until there is no air left to breath out.

There are expensive machines for measuring an individual's total lung capacity, but we don't have access to them in this lab. We have measuring tape and weighing scales. We need a value we can measure with our inexpensive tools that we can use to indirectly predict an individual's total lung capacity. That is, we want something we can easily measure on the bodies of two individuals so that if the measurement of the first person is 50% higher than the same measurement on the second person, we can be reasonably certain that the first person's total lung capacity is 50% greater than that of the second.

- The hypotheses for predicting total lung capacity will be written out on the board as they are suggested.
- Refine the suggestions until you have several alternative hypotheses, all of which you can easily test in today's lab with just a measuring tape and a weigh scale.

Write the final versions of the two most easily tested hypotheses in the boxes below. The instructor will provide the third hypothesis.

1st hypothesis:

2nd hypothesis:

3rd hypothesis:

Deriving testable predictions from your three hypotheses.

If two values correlate well, what will happen if you graph them?

What data will you collect to test your three hypotheses?

If one of the hypotheses is correct and the others are wrong, what can you predict about plots of the three data sets obtained from your data collection?

Exercise 3.1

Developing an experiment to test your three hypotheses.

In your group of three or four, spend a few minutes to come up with an experimental plan.

- Determine
1. What you will measure and how you will measure it ?
 2. What you will calculate?
 3. What you will graph?
 4. How you will decide whether to accept or reject each hypothesis?

After a few minutes, each group will present its ideas to the class and the instructor will fuse the ideas into one well-designed protocol that everyone will follow. Because you need large data sets to analyse, the entire class will end up pooling its data.

Once the instructor has fused all the ideas into one protocol for everyone to follow, write down the steps here:

1. What you will measure.

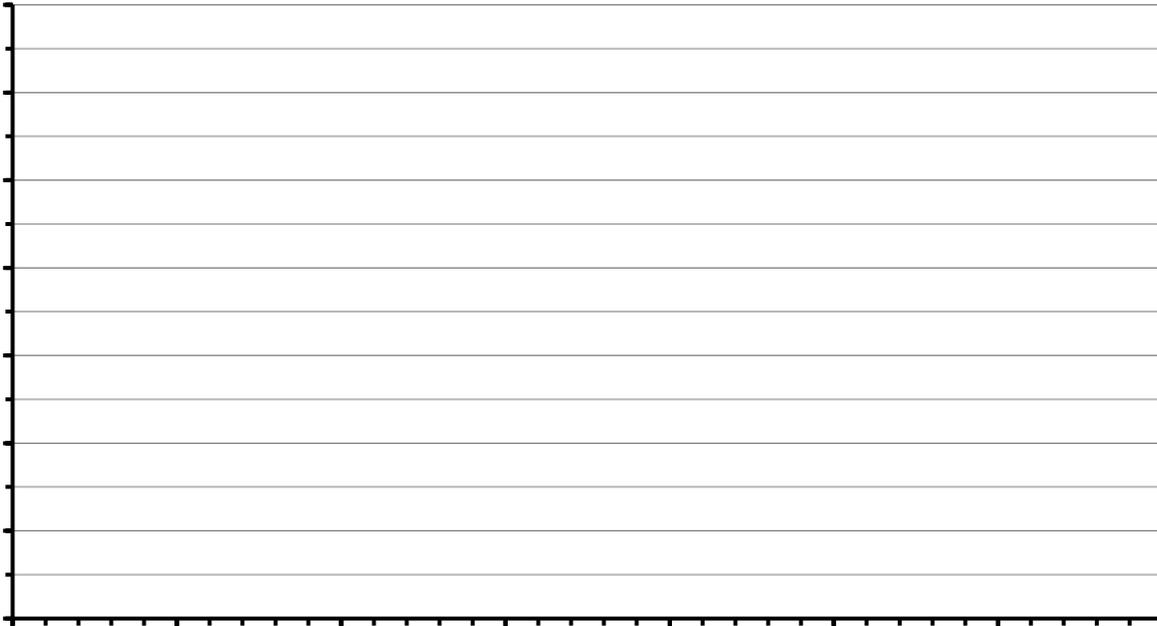
2. What you will calculate

3. What you will graph

4. How you will decide whether to reject or accept each hypothesis

6. Analyzing And Interpreting Your Data

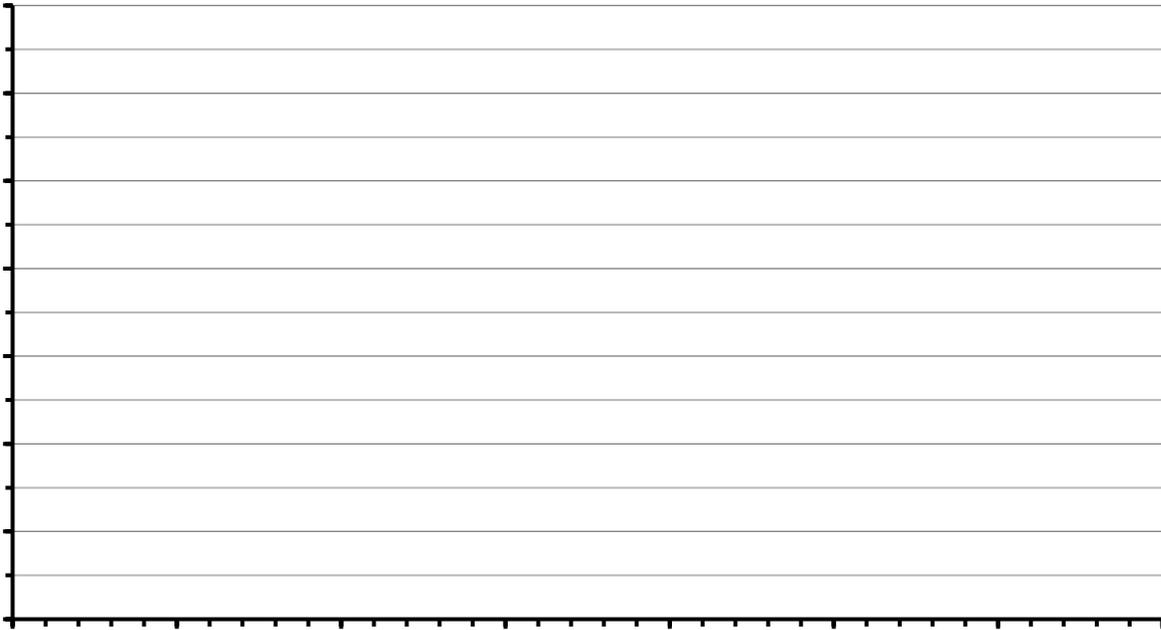
In the graphs below, plot your data sets. Under each graph, indicate whether the relationship provides evidence for accepting or rejecting the hypothesis.



Hypothesis:

Result:

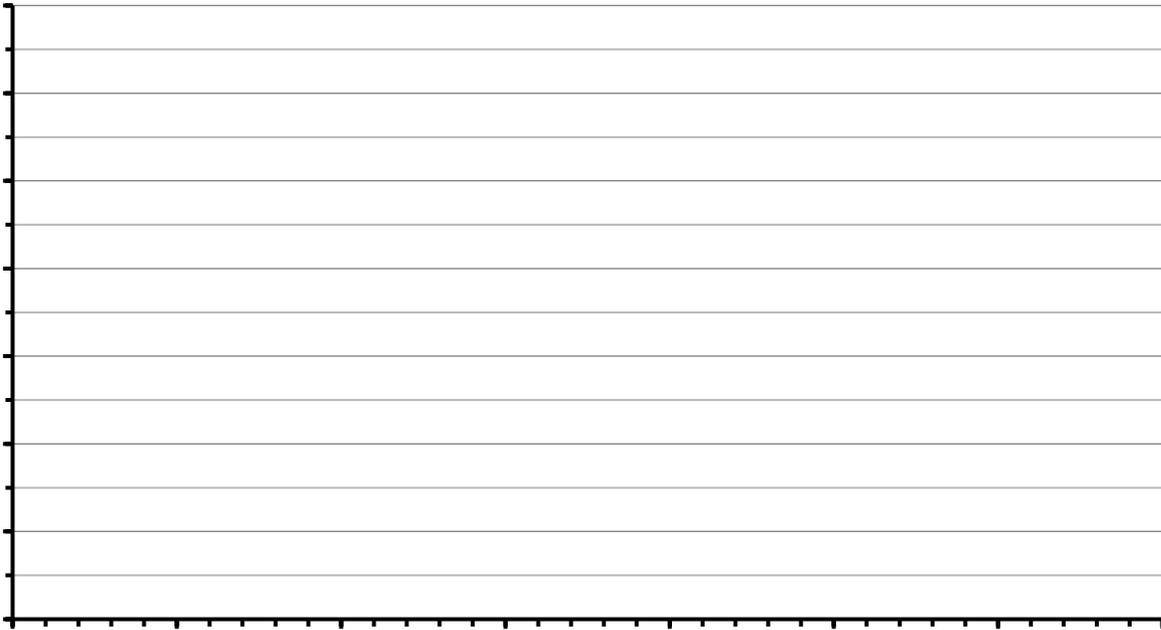
Accept or reject hypothesis? Why?



Hypothesis:

Result:

Accept or reject hypothesis? Why?



Hypothesis:

Result:

Accept or reject hypothesis? Why?