**Statistical hypotheses, Scientific hypotheses, and Predictions**

**Scientific hypotheses** are testable and falsifiable proposed *explanations* to account for observed patterns or trends. Ideally, for any given hypothesis-driven question, you will generate multiple scientific hypotheses at the same level of analysis, which you can then attempt to falsify by generating predictions, collecting data, and performing statistical tests on your data to determine whether your predictions are true.

Some examples of scientific hypotheses to explain why male birds sing are:

* Male birds sing to attract mates
* Male birds sing to exclude territorial rivals
* Male birds sing to warn other birds of approaching predators

**Statistical “hypotheses”**, on the other hand, are *statements* about whether or not a pattern or trend or difference is present in your data. Statistical tests are used to distinguish between the null hypothesis and one or more “alternative hypotheses”.

The “Null Hypothesis” (also called “H0”) states that there is no pattern or trend in the data (e.g. there is no difference between groups, no relationship between two variables).

An “Alternative Hypothesis” (also called “HA”, or “H1, H2, etc. if more than one alternative exists) states that there is a distinct pattern or trend in the data (e.g. there is a difference between groups, or a relationship between two variables).

Statistical hypotheses are NOT the same as scientific hypotheses. Statistical hypotheses are not alternative explanations for observed patterns or trends; they are simply statements about whether or not a pattern or trend exists. Statistical hypotheses are used to determine whether patterns or trends are present in descriptive studies, or to test predictions in hypothesis-driven studies.

For example, in an observational study about which sex sings more frequently in chickadees, your statistical hypotheses might be:

* Null hypothesis (H0): “There is no significant difference in the number of songs that are performed by male and female chickadees.”
* Alternative hypothesis (HA): “there is a significant difference between males and females in the number of songs they perform.

**Predictions** are statements about patterns, trends, or differences between groups. Statistical hypothesis tests are generally required to determine whether or not a prediction is correct.
*Critical predictions* are predictions that, if found not to be true, would refute the corresponding hypothesis. An example of a critical prediction for the hypothesis that male chickadees sing to warn relatives about the presence of predators is that more songs should occur when predators are present.

**Recommended Reading:**
Platt (1964) - Strong Inference

McPhearson (2001) - Teaching and learning the scientific method

**Descriptive (observational) vs. Hypothesis-driven studies**

**Descriptive studies**

Descriptive studies attempt to **IDENTIFY patterns and/or trends.** These studies do NOT require use of the scientific method, or the formulation of alternative scientific hypotheses. The only requirement for a good descriptive study is the collection of detailed, quantitative observational data.

Some examples of **questions** that could be answered using descriptive studies include:

* In sex, which sex (males or females or both) performs singing behavior?
* At what time of day do chickadees sing?
* How long does a typical singing bout last?
* Is there a characteristic height above the ground at which singing tends to occur?
* What are the characteristic body movements that accompany singing behavior?
* Do individuals differ in their singing behavior?

Predictions:Descriptive studies *can* involve predictions—for example, you might predict that male chickadees would be the only sex that sings because this pattern is characteristic of all songbirds in temperate climates. But predictions are *not required* for a descriptive study; even if you had no idea which sex sings, you could still go out and record the sex of each chickadee you observe singing.

Hypotheses: Descriptive studies do not involve scientific hypotheses, because descriptive studies attempt to *identify*, rather than *explain,* patterns and trends. However statistical hypotheses and statistical tests should be used, if possible, to verify the presence of patterns or trends in your data.

**Hypothesis-driven studies**

Hypothesis-driven studies attempt to **EXPLAIN observed patterns and/or trends.** These studies DO require the use of the scientific method, and the formulation of alternative hypotheses. These studies generally answer questions about *why* a behavior occurs.

The steps involved in performing a hypothesis-driven study using the scientific method are:

1. Formulate multiple hypotheses (on the same level of analysis) for why this behavior occurs.
2. Generate predictions for each of your alternative hypotheses. Ideally, at least some of these should be critical predictions (i.e. predictions that, if found not to be true, would refute the corresponding hypothesis).
3. Perform experiments and/or observations to determine which critical predictions are true.
4. Formulate statistical hypotheses and perform statistical tests on your data to determine whether they fit with your predictions.
5. Based on the results, determine whether your hypotheses were falsified or supported.

Examples of questions that could only be answered using hypothesis-driven studies include:

* Why do male chickadees sing?
* Why do chickadees only sing in the morning?
* Why does most singing occur while birds are on the ground?