What are field studies?
Research projects that are conducted outdoors ("in the field"); this may be in the school yard or at a remote location such as a park or beach. Field studies may be DESCRIPTIVE (e.g. preparing a list of all of the different types of plants found on campus, or comparing the types of birds observed at two different locations) or MANIPULATIVE (where some environmental VARIABLE is altered and the outcomes are measured).

Why conduct field studies?
Students learn best by hands-on opportunities; they are more likely to retain information and understand its relevance when they actually apply the information. Field studies can incorporate many different subject areas; for example, a project to map plant life on campus will include biology, math, geography (in addition to the mapping process, students may research the plants and determine their native countries), and may also incorporate English and art. Field studies require students to work cooperatively and provide first-hand evidence of the need for proper experimental design (repetition, hypothesis testing, data analysis, etc.).

How do we get started?
The type of project chosen will depend on the age and limitations of the students, as well as the comfort level of the teacher. It is best to start with a simple project; the outcomes of the simple project will often suggest follow-up projects.
1. Select a desired outcome.
This may be hypothesis-based, or may simply be a final product. Here are some examples:
   a. Students will work together to produce a vegetation map of the playground. Outcome: an annotated map and plant species list; extensions may include video/photo guide to plants on campus, signs to identify plants, development of a nature trail...
   b. Students will make a seasonal study of birds around the school. Outcome: report including lists of bird species, photos of birds and graphs showing the seasons during which they are likely to be seen; extensions may include an audio library of bird songs, fabrication of bird feeders and study of feeding preferences of certain types of birds, a feather "library", research projects about specific bird species—nest structure, egg color, etc...
   c. Students will monitor water quality in the intracoastal waterway. Outcome: Report (graphs). Students should learn that environmental conditions can affect water quality. Students will apply chemistry (and physics) and will see how the sciences are integrated. This study could be expanded to be a comparison between locations (e.g. areas with lots of boats vs. "pristine" areas). Studies could also correlate wildlife abundance with water quality measurements.
2. Determine what needs to happen in order to reach the desired outcome. What are the steps/activities that will have to occur, and how long will each one take?
there be cooperation/data sharing with other classes? Is this a one month/year project or could it continue from year to year?

3. **Set time frames for the various activities.** Be realistic! Remember that during a class period you need to allow time for getting to and from the desired location, as well as time for cleanup (perhaps). Remember that weather may cause cancellation of planned field days—you may need to be flexible! Also, for coastal studies, tide state may be critical... Try and plan for more days than you think you will need so you have "back-up" dates. You may be able to collect some data in the field and do analysis of other samples later in the classroom. Plotting the agenda on a calendar will give the students goals to shoot for and will help remind you when something is approaching that you need to prepare for.

4. **Coordinate with other teachers who might be involved.** Other teachers may have resources that you can use, and vice-versa. Components of the science project could double as an art project, or written research assignment for English class...

5. **Paperwork...** Parental permission slips might be necessary; at the very least they are a good idea as you may be asking parents to send the child to school with bug spray on, or with special clothing... Contracts with the students are recommended—they let the students know the rules, and outline what will happen if students violate the rules. You may need to arrange for buses for off-campus travel.

6. **Other logistics:**
   Collect resource materials and supplies for the project (guide books, data sheets, sampling equipment, etc.) Do a preliminary assessment of the field site—look for poison ivy, black widow spiders, fire ants, etc...not because you can't necessarily do the study if these things are present, but because you need to at least be able to warn students of their presence. This may also give you the opportunity to research some of the species found in the area so you can answer questions raised by the students! Know your restrictions when it comes to the use of bug spray, sunblock, etc...

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**What equipment will I need?**

The answer to this depends on the type of study you are planning to do. Below are some suggestions for the three example studies listed earlier. Bear in mind that there may be alternate ways of accomplishing the same goal...

- **Vegetation map:** tape measures (cloth ones are recommended), compasses, pencils, gridded paper, blank paper, plant guide books. Optional: flagging tape and stakes to mark off the survey area, plant presses, cameras, quadrats, protractors.
- **Bird study:** binoculars, log book, pencils, bird books. Optional: bird song guide, camera, weather station (e.g. temp, humidity).
- **Water quality study:** Tape measures, quadrats, secchi disk, water sampling bottle, depth stick, seine net, dip nets, test kits (nutrients, coliform bacteria), DO meter, pH meter, refractometer, thermometer, field guides, tide tables, booties/alternate footwear, buckets, waterproof data sheets, pencils.
Important concepts that the students will need to learn (some may be best accomplished through trial and error...!)

**Variance/error**--This can be simply demonstrated by passing around a strip of paper and a ruler and asking students to write down the length of the piece of paper. If you are sneaky, cut the strip of paper to an "odd" length, e.g. 12.25 mm). Collect all of the measurements and list them on the board (ideally they will not all be the same!). Have students calculate the mean, then graph the mean and range as a bar graph with error bars. Also note that if you do not specify the units to be used, most students will measure using the "inch" side of the ruler. In science, the metric system should always be used.

**Replication**--Use the "Too Many Crabs" exercise, but have students only take one 1 cm² count, then use this to estimate population. Then have them do the 10 replicates and estimate the population using the mean of the 10 samples. The estimate made using the mean should be closer to the actual number than the single count estimate.

**Random sampling**--If students always drop the square from the same spot in the "Too Many Crabs" exercise, they will find that their estimate is BIASED. In an ideal situation, there would be some way to randomize the sampling (e.g. by spinning the paper that has the crabs on it, or by closing one's eyes when dropping the square). In field studies, this is often done by dividing up the study area into a grid system and using randomly-generated numbers to pick the spots where the quadrats are placed. This can also be accomplished using a transect and random numbers. Random numbers can be generated using Excel.

**Hypothesis**--this is the question that is going to be tested. Some studies that are purely descriptive may not have an obvious hypothesis, but with a little thought, you should be able to come up with one. For example, the plant mapping study's hypothesis may be that there will be no more than 20 plant species in the school yard. In science, the hypothesis is typically something that you try and prove wrong (because you can disprove something statistically, whereas you cannot prove something is right by using statistics...)

**Justification**--this is a concept that students often find difficult to grasp--yet it is one of the most important parts of a scientific study. The justification explains the importance of conducting the research—it answers the question, "So what?" or, "Who cares?" The justification for the plant mapping study might be to produce a plant book for use by other students, or to provide a baseline for future studies that might show the impact of foot traffic or other activity on the plants.

**Variables**--anything that might affect the outcome of an experiment. These are often environmental factors like temperature, sunlight, salinity, etc. It is important to try and think of all the variables that might impact your results, then try and CONTROL as many of those as you can (e.g. if you want to study how temperature affects plant growth, you should try and give all plants equal light so that differences between plants cannot be attributed to different light conditions). In the plant mapping study, the school's landscapers could be considered a variable, and should probably be consulted before starting the mapping project to be sure that no major re-plantings are going to occur in the middle of your project!
The scientific report

The outline for this will vary somewhat, according to the agency requesting the report (e.g. the state science fair may have a slightly different outline than the Journal of Experimental Biology...). A generic outline is given below:

Abstract: Usually has a word count limit (e.g. 500 words, which to students may seem like a lot!). This should be a concise summary of the experiment and its results. Start with a description of the problem/reason for doing the experiment. Briefly state what was done and why, then outline the results and any overall conclusions.

Introduction: Gives a thorough background including why the project was taken on, any previous similar projects and any research pertaining to the project. Sources for all of the information given in this section should be provided (by footnotes or citation). The introduction may include a map of the area (if appropriate).

Materials and methods: This section should outline step by step how the project was done. Ideally, someone should be able to duplicate the experiment by following the instructions given here. Diagrams of apparatus/methods should be given where appropriate. The answers to questions like "When? Where? How? How many?" should be in this section.

Results: This is the data section. All measurements, numbers, graphs, etc should be in this section, along with a description of the overall findings of the study. Lists of raw numbers are generally NOT included here (although they may be provided in an appendix); means, variances and graphs are the types of information that should appear here. If statistics are done, the statistical tests should be described and the confidence limits given.

Discussion and Conclusions: This is the section that analyzes the data and draws conclusions from it. This is also the section where any problems that arose during the study can be described and any possible impacts of those problems can be laid out. This is the section of the report where the researcher gives the justification for the study--"the data proves that..."

References/Literature Cited: The format of this section will vary with the agency or journal. Pick one style and be consistent (check with the English teacher).

Appendices: This is where students can provide raw data (you may want this, especially if you plan to do follow-up studies), complete species lists, etc (anything too lengthy to include in the results section).

Tables and Figures: graphs, maps etc. These can be incorporated into the text, or provided as separate pages, with legends to explain them.