Note: This question has a lot of words. This is because we're giving you a lot of background. Don't read too much into the word count.

Background 0: Read the paper P. Rosenbaum (2001), "Choice as an alternative to control in observational studies", Statistical Science, which is posted here. This will be helpful in answering the question below about designing an observational study on environmental influences on eating and physical activity (question from Rosenbaum's *Observational Studies,* page 359).

Environmental influences on eating and physical activity.

Background 1: Successful planning of an observational study requires a genuine puzzle in a context that is familiar. The context needs to be familiar so one can think concretely about plausible sources of bias, grounds for doubt, and what to do about them. In advanced scientific work, the context may be familiar only to the relatively few people who conduct studies in that area, but for a textbook problem, the context needs to be generally familiar. There is evidence that obesity is increasingly common in the United States; see Kuczmarski, Flegal, Campbell, and Johnson (1994) for evidence from the National Health and Nutrition Examination Survey. The question is: Why? Presumably it reflects changes in either eating patterns or physical activity or both, but the question is: What caused those changes?

Background 2: A thoughtful survey of possible contributing factors to changes in the obesity rate is given by French, Story, and Jeffery (2001). They write : "Documenting the environmental influences on population physical activity and eating behaviors has posed an even greater challenge than documenting individual behaviors because such influences are difficult to define, measure, and study experimentally." Over roughly 25 years, they document: (i) dramatic increases in the consumption of cheese, up 146%, and soft drinks, up 131%, but a 3% increase in grams of fat consumed per day, (ii) dramatic increases in the number and use of restaurants, especially fast-food restaurants, and the commercial failure of several efforts by fast-food restaurants to market lower-fat options, and (iii) growing portion sizes, for instance, for soft drinks. They discuss convenience foods, pizza, "take-out," women working outside the home, the large amounts spent on food and restaurant advertising, and the relative prices of different foods. Concerning physical activity, they discuss television, VCR's, computer games, and health clubs. Many possible hypotheses, and a context that is, well, familiar.

Addressing all of these potential influences at once is quite challenging. Instead, consider the hypothesis that food prepared by fast-food restaurants plays a large role, versus the alternative that its role is minor.
(i) Can you think of a control group, that is, a group that rarely or never eats in fast-food restaurants? Preferably, the control group would be formed not by food preferences, but rather by something ostensibly irrelevant. Can you think of more than one control group of this sort?
(ii) Are these control groups representative of the US population? If not, can you find an exposed group or several exposed groups, perhaps also unrepresentative, but quite similar to the controls?
(iii) Can you identify haphazard limitations on access to fast-food restaurants, limitations that can affect diet and physical activity only through limitations on access?
(iv) What outcomes would you measure?

(v) What would constitute a coherent treatment effect? [Lecture on May 7. Also in textbook.]

This problem is loosely based on the above. You are given the data set below. You may assume that these are matched-pair data, where a large number of covariates have been used to create pair-matches between one treated (Western diet) and one control (Mediterranean diet). You can think of the outcomes listed as the body-mass index of the individual.

pair	treated	control	difference	rank
1	33.4	30.5		
2	31.1	33.5		
3	35.0	31.3		
4	45.4	28.6		
5	29.7	29.7		

(vi) Use the framework of the Wilcoxon signed-rank test to complete the table above. Report the test statistic and p-value from a Wilcoxon signed-rank test.

(vii) Compare the results of the Wilcoxon signed-rank test to (a) a matched pairs t-test (you can pool the standard deviations and assume that Student's approximations are reasonable), (b) an unpaired, two sample t-test. Give p-values and interpret under the assumption of no unobserved confounding.

(viii) Provide a paragraph or two discussing where these three forms of inference depart, and why they depart. Imagine you're trying to have this conversation with a researcher who is unfamiliar with the technical considerations about choosing between the three methods. Take a stand about which one to use and why. (It'll be hilarious if you try to convince me that the best choice isn't Wilcoxon signed-rank. Go for it. I dare you. It'll be a fun way to lose points.) Mostly, points will be awarded for your reasoning and attention to design and data.