CHAPTER 25: DELIBERATE BIAS: HOW CONFLICT CREATES BAD SCIENCE

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IMPEDIMENTS TO SCIENTIFIC PROGRESS

When proper scientific procedure is undermined by conflicting goals so that it results in deception, we say it is biased. This form of bias is prevalent in advertising - companies universally advocate their products, emphasizing product assets while concealing product faults and concealing the advantages of competitor products. You don't expect an advertisement from a private company to offer a fair appraisal of the commodity. But bias even exists in the way that states promote their lotteries by advertising the number of winners and money "given away" without telling you the number of losers and money taken in.

Introduction

Deliberate bias occurs in science as well as in business and politics. The potential for bias arises when a scientist has some goal other than (or in addition to) finding an accurate model of nature, such as increasing profits, furthering a political cause, or protecting funding. The environmental consulting firm that renders an opinion about the environmental effects of the latest subdivision may not give a completely accurate assessment, if the future work that this firm receives from developers is likely to depend on what they say. If the developers don't like the assessment, they will likely find another environmental next time. Thus there is a conflict between obtaining an unbiased model, and making the largest profit possible. In these cases, the scientists (and everyone else) are motivated to present biased arguments. There are many situations which present a conflict between scientific objectivity and some other goal; a few cases will be covered at the end of the chapter. First, however, this chapter will delve into characteristics of bias that apply broadly -- are not example-specific -- and ways to counter it.

Deliberate Bias: flawed representation of science and how to recognize it

The attempt to deceive others about science may take many specific forms. At a general level, arguments may avoid science entirely, or they may instead appear to follow scientific procedure but violate one or more elements of the scientific method (models, data, evaluation, revision). The next few sections of this chapter describe different kinds bias that apply broadly.

This section focuses on properties and indicators of bias that typically lie outside of the science itself -- bias in people's reactions to scientific result, bias in articles written to influence your opinion of scientific results, and general predictors of bias. These generalities are useful in that they enable you to detect bias without knowing the specifics of the situation -- you don't need to know the details of the scientific studies to discover the bias. Sections (5)-(7) then address ways that studies -- the science itself -- can be biased.

Look for Conflict of Interest:

An easy clue in anticipating deliberate bias is conflict of interest. If another party's goal differs from your goal, and your goal is to seek the scientific "truth", then there is a good chance that the other party is biased -- just as you may be biased if your goal differs from seeking scientific truth. Service on many Federal panels requires a declaration of all conflicts of interest in advance (and you will be excused from consideration where those conflicts lie). That is, the government avoids even the appearance of bias based on the existence of conflict, without looking for evidence of actual bias. However, in our daily lives, we are confronted with conflict at every turn, and we can't simply avoid bias by avoiding interactions involving conflict (e.g., every time you make a purchase, there is a conflict of interest between you and the seller). Thus, being aware of conflict is a first step in avoiding bias. But you can also benefit by watching for a few symptoms of bias.

Bias in write-ups for the public: are they trustworthy?

Articles and claims written for public consumption often have characteristics that allow you to decide whether to trust the claims. These articles (reports, commentaries, and accounts) will typically summarize or describe the significant outcomes of a study, they will not be the technical study itself -- they in fact can operate when the underlying science is good or bad. An article's trustworthiness generally lies in how much or little it overstates the significance of the work and simplifies the details, as listed below. Of course, there may be legitimate reasons why an otherwise trustworthy source omits some of characteristics indicative of trustworthiness -- there may not be room in the article. But awareness of these points is often useful:

TOPIC	TRUSTWORTHY	SUSPICIOUS
Claims	Modest	Sensational, play to emotions, too good to be true
Original sources	Provided (be wary of circular reporting)	Neglected
Details of data	Provided	Omitted
Alternative interpretations	Noted and discussed	Omitted
Replication of work	by independent sources	Absent or limited to a selective subset
Source of work	Provided, from a reputable researcher, institution	Unknown, private
Source of notification	From 3rd party with no vested interest	A party who gains by convincing you, an advertisement
Uncertainties	Noted	Omitted
Nature of result	Sufficiently complex	Overly simple, one-sided, far reaching
Testimonials	Absent	Abundant
Funding	Funders have no partiality	Funders want a specific result

Non-scientific arguments: bias in someone's response to a study

Sometimes, someone is so biased that they resort to lines of reasoning and argumentation that are clearly in violation of science. **These arguments do not involve the actual science of a study** -- they lie outside of the science itself -- and they can be detected without looking at the data or analysis. No doubt, many of them are already familiar to you, as given in the following tables. These arguments will typically be from people not associated with a study, being given as (flawed) reasons why someone does not accept a conclusion or why they want to discourage others from accepting it. For example, lawyers, politicians, administrators and members of the non-scientific public may use these arguments to justify refusing to accept a claim they have been told about.

ARGUMENTS IN VIOLATION OF THE SCIENTIFIC METHOD	
Appeal to Authority	Appeal to authority is the defense of a model by indicating that the model is endorsed by someone well known (an authority). A model should stand on its own merits. The fact that a particular person supports the model is irrelevant, though the specifics of what they have to say may assist you in evaluating the model.
Character assassination of opponent	Character assassination is the attempt to discredit someone's character (e.g., point out that they associate with undesirable people, etc.). The character of somebody is irrelevant to the evidence they present that supports or refutes the model. We should evaluate the evidence, not the person presenting it.
Refusal to admit error	Refusal to admit error is the refusal to specify the conditions under which a model should be rejected or the refusal to accept its refutation in the face of solid evidence against it. All models are false, and anyone who refuses to discuss how their model could be seriously in error is obscuring a fair appraisal of their model (or is using an unfalsifiable model). In science, every model has imperfections which may warrant its abandonment. Someone advocating a model may want to suppress all doubt about its imperfections and thus suggest that it can't be wrong. That attitude is a sure sign that the person is biased.
Identify trivial flaws in an opponent's model	This violation refers to the practice of searching for unimportant details about a model that are false, and using those minor limitations as the basis for refuting the model. The fact that all models are false does not mean that all are useless. Yet it is a common trick of lawyers to harp endlessly on the fact that a particular model advocated by their opponent is not perfect and thus should be abandoned.

ARGUMENTS IN VIOLATION OF THE SCIENTIFIC METHOD	
Defend an unfalsifiable model	A model must be falsifiable to be useful. "Falsifiable" merely means that it could be refuted if the data turn out to be a certain way. An unfalsifiable model is one that cannot be refuted no matter how the data turn out. Creationists, for example, adopt and then defend an unfalsifiable model. An unfalsifiable model is one that is framed so that we could never gather data to show it is wrong. By contrast, science is predicated on the assumption that all models will eventually be overturned.
Require refutation of all alternatives	This is special case of defending an unfalsifiable model, and it is subtle. It is takes the form of insisting that a class of models is correct until all variations of them have been rejected. As an example, we might refuse to accept that the probability of Heads in a coin flip is 0.5 unless we reject all alternatives to 0.5. Whereas it is possible to refute that the probability of Heads in a coin flip is 1/2, it is impossible to refute that the probability of Heads is anything other than 1/2, because that would mean showing it is exactly 1/2. (It would take an infinite number of flips to reject everything other than 1/2.) This argument also takes the form of claiming that there is some truth to a model until it has been shown that there is nothing to it at all.
Scientific-sounding statements	Scientific "buzz words" are often effective tools in persuading a naive audience that a speaker is saying something profound.
Post hoc rationalization of unexpected outcomes	Post hoc justifications are made after the fact, often to bolster a particular model. It is typically easy to reinterpret data to explain outcomes that were unexpected. These types of arguments usually invoke properties of the data that cannot be refuted without additional testing because they are idiosyncratic and specific to the situation.

ARGUMENTS IN VIOLATION OF THE SCIENTIFIC METHOD	
Heresy does not imply correctness	Just as some people will believe a conspiracy theory about almost anything, many of us are sympathetic to the independent thinker who goes against the consensus and discovers something totally new. Unfortunately, most people who defy the consensus are wrong. The fact that a person has an off-the-wall or anti-establishment theory to propose is not a reason to assume that they must be on the right track.
Build causation from correlation	It is an easy trick to describe a correlation that appears to defy a causal model, but as we know from previous chapters, correlations can be misleading.
Unexplained is inexplicable & either-or arguments	A common ploy is to attack a theory (e.g., evolution) on the grounds that it doesn't explain some observations, hence that it must be wrong. (Of course, since all progress is built on model improvement, it is absurd to suggest that a currently accepted model should have to explain everything.) However, when such a tactic is combined with an either-or proposition -- that if theory X isn't right, theory Y MUST be -- it can be an effective way of erroneously convincing an audience to support a flawed model.
Use anecdotes as evidence of generality, ignore the bulk of evidence	An anecdote is an isolated, often informal observation made without a systematic, thorough evaluation of the available evidence. As a selected observation, it is not necessarily representative of the relevant observations, and indeed, an anecdote is often used when an argument would not be supported by the bulk of evidence. A testimonial used in defense of a model is essentially an anecdote, because it can be chosen selectively and need not be representative.

Gaining Social Acceptance of Studies:
bias independent of the actual study

Bias can also operate in the way a society responds to and accepts science. This possibility may seem strange, because this level of bias does not involve the actual scientific work at all. However, when science is used to inform policy, the standards that must be met will often be decided independently of the work and may even be established before the work is done. And the presentation of science to the public can influence their acceptance of it, as with biased advertisements. It is at these levels that the process can be biased regardless of how the work itself is conducted.

Influence regulatory agencies. Many governmental decisions about acceptable policies and practices are established by committees. Individuals and corporations with an interest in those regulations can bias the process by getting membership on those committees so that the decisions reflect their interests.

Hamper the political process. Our judicial system provides various legal procedures to challenge the implementation of new plans and policies, commonly lawsuits. The filing of lawsuits will often delay implementation of new rules, giving an organization more time to continue operating under its current rules.

Influence public opinion. Convincing the public of a viewpoint can be an effective way to help ensure its acceptance by the political machinery. Politicians respond to public opinion. There are in fact few constraints on what the public is told, so if the public can be convinced of a distorted view in advance of a study (or even after the study), the bias is more likely to be accepted.

Control the null model.   As noted in an earlier chapter, many evaluations are based on a null model approach: the null model is accepted until proven wrong. To "control" the null model means to "choose" the null model. Choice of the null model can have a big effect on the outcome of even the most unbiased scientific evaluation for the simple reason that a null model is accepted until proven guilty. Any uncertainty or inadequacy in the data will thus rule in favor of the null model. By choosing the null model, therefore, many of the studies testing the model will "accept" it, not because the evidence for it is strong, but because the evidence against it is weak. As a consequence, the null model enjoys a protected status, and it is to anyone's advantage to choose which model is adopted as the null model. Choice of the null model in this sense does not even mean developing it or proposing/inventing it. Given a set of alternatives decided upon in advance, controlling the null model means simply the selection of which model from that set is adopted.

Consider the two alternative models that might be used in approving a new food additive for baby formula:

a. food additives are considered harmful unless proven safe to some limit

b. food additives are considered safe unless shown to be harmful

Model (a) as the null model requires a rigorous demonstration of the safety of a food additive before it is approved. In contrast, model (b) as the null model requires that an additive can be used until a harmful effect is demonstrated. As noted in the Data chapters, an enormous sample size might be required to demonstrate a mild harmful effect, so a harmful product could reach market much more easily under null model (b) than under (a).

Choice of the null model represents a powerful yet potentially subtle way in which an entire program of research can be biased. Every other aspect of design, models used, and evaluation could meet acceptable standards, yet choice of a null model favorable to one side in a conflict will bias many outcomes in fa-

Biasing Science itself: in study design and conduct

The obvious way to bias science is in the design and conduct of the study -- when deciding how to gather data and then when gathering data. The template for ideal data presented in earlier chapters is a strategy for producing data with a minimum of bias. But the template can be applied in many ways, and someone with a goal of biasing data can nonetheless adhere to this template and still generate biased data. Let's consider a pharmaceutical company testing the efficacy of a new drug. How many ways can we imagine that the data reported from such a study might be deliberately biased, when the trials are undertaken by the company that would profit from marketing the drug? The following table lists a few of the possibilities.

VIOLATION OF ACCEPTED PROCEDURE	IMPACT
Change design in mid-course	An investigator may terminate an experiment prematurely if it is producing unwanted results; if the experiment is never completed, it will not be reported.
Assay for a narrow spectrum of unlikely results	The public well being is many-faceted, and a product is unlikely to have a negative impact on more than a few facets. With advance knowledge of the likely negative effects (e.g., a drug causes brain cancer), a study can be designed to purposefully omit measuring those negative effects and focus on others (e.g., colon cancer). Were the subjects a fair sample of the relevant population? The medicine might be more effective on some age groups than others, so the study might be confined to the most responsive age groups (determined in preliminary trials). While the data would be accurate as reported, details of the age group might be omitted to encourage a broader interpretation of the results than is warranted. (One commonly observes a related phenomenon in car commercials – a company pointing out the few ways in which their product is superior to all others.)

VIOLATION OF ACCEPTED PROCEDURE	IMPACT
Conceal the protocol	It is easy to write a protocol that conceals how the study was actually conducted in some important respects. For example, was a blind design really used? Although a blind design exists on paper, it is possible to let patients and staff know which patients belong to which groups. Indeed, patients can sometimes determine whether they are receiving the drug or placebo. Were the controls treated in exactly the same manner as the group receiving the medicine? It is possible to describe countless ways in which the control group and treatment group were treated similarly, yet to omit ways in which they were treated differently. The medicine might be given along with some other substance that can affect patient response, with this additional substance being omitted from the placebo.
Small samples	Science often assumes "innocent until proven guilty" in interpreting experiments designed to determine if a product is hazardous. Small samples increase the difficulty of demonstrating that a compound is hazardous, even when it really is.
Non-random assignments	Most studies, especially those of humans, begin with enough variation among subjects that random assignment to control or treatment groups is essential to eliminate a multitude of confounding factors. Clever non-random assignments could produce a strong bias in favor of either outcome.

There are obviously additional ways to bias studies. For example, the description of drug company tactics at the beginning of this chapter listed several specific examples: **ignore alternatives**, **comparisons confounded by dose differences**, and **test the wrong age group**. However, it is also important to recognize that bias can creep in *after* the work is done, as addressed next.

Biasing Science itself: in evaluation and description of results -- after the data have been gathered

Even when the raw data themselves were gathered with the utmost care to avoid bias, there is still great opportunity for bias. Bias can arise as easily during data analysis, synthesis and interpretation, as during data gathering. This idea is captured in the title of a book published some years ago, "How to Lie With Statistics." Two methods of biasing evaluation are (i) telling only part of the story, and (ii) searching for a statistical test to support a desired outcome. Again, these are a few of the major types of abuses. The description of drug company practices (above) gave some specific examples that are not encompassed by the two cases below: broaden the market, and using ghostwriters to put a favorable spin on the outcome.

Present only part of the story

A powerful and seeming 'honest' method of deceit is to omit important details. That is, nothing you say is untrue, it's just that you avoid saying part of the truth. In science you can do the same thing – present only part of the results. For example, a drug that was tested might be free of effects on blood pressure but elevate cholesterol. Telling an audience that there was no effect on blood pressure would be accurate. It's just that they would like to know everything that was found. Of course, advertisers do this all the time – describe only the good aspects of their product. In a court case, the defense will only present the data that they have that tends to exonerate their client. So we kind of expect it. But in science, this is unacceptable. Furthermore, there is a long gradation of omission that runs from innocent to totally dishonest.

Throw out unwanted results. The most extreme and dishonest form of omission is throwing out results because they do not fit the goal. We often assume that a study reports all relevant results. But studies often have (valid) reasons for throwing out certain results. Throwing out results can also bias a study, however. If we flip a coin ten times, and we repeat this experiment enough times, we will eventually obtain 10 heads in some trials and ten tails in others. We might then report that a random coin flip test produced ten head (or tails), even though the entire set of results produced an equal number of heads and tails - by failing to report some results, we have biased those that we do report. For example, a product test may have been repeated many times, with the ones finally published being limited to those favoring the product.

A seemingly less innocuous version of throwing out unwanted results is to not report some studies. Reporting only some of the data is bad, but researchers commonly do studies that they never report -- for legitimate reasons such as the findings are not interesting and the paper would be difficult to publish if filled with uninteresting findings. The selective reporting of some studies but not others offers an opportunity for bias, however.

Terminate unfavorable studies early, so they don't `count.' A less extreme but equally improper form of discarding results has commonly been used by drug companies. They fund studies into the efficacy of one of the drugs in their research pipeline. In some cases, they have terminated studies where the early results look unfavorable; if the study is never finished, then it doesn't get published. Alternatively, they have blocked publication of completed studies that they funded, so that the results never see the light of day.

Publish distorted summaries of the work. Regardless of what the actual science shows, if there is a lot at stake, a company with a vested interest in the outcome may hire 'ghostwriters' to publish summaries and reviews of the study that distort the actual findings. If the original study is lengthy and complex, most readers may only ever bother to read the summaries/reviews.

Lie with statistics:

There are hundreds of ways to conduct statistical tests. Some study designs fit cleanly into standardized statistical procedures, but in many cases, unexpected results dictate that statistical tests be modified to suit the circumstances. Thus, any one data set may have dozens to hundreds of ways of being analyzed. In reporting the results, someone may bias the evaluation step by reporting only those tests favorable to a particular goal. We should point out that this practice offers a limited opportunity to bias an evaluation. If the data strongly support a particular result, it won't be easy to find an acceptable test which obscures that result. Of course, a biased person might merely avoid presenting those results or avoid presenting a test of that hypothesis. There are many ways to selectively present data, as are listed in the table below.

Table: Ways to bias statistics and graphics:

STRATEGY	EFFECT
Avoid presentation of unfavorable results and tests	Not showing something is an effective way to conceal it
Group different categories of data to obscure results	The grouping can bury an effect that occurs in just one of the categories
Chose an appropriate scale to display results favorably	Since many people will look only at the visual appearance of a graph, the scale can have a large effect on perceptions.
Transform the data before testing	Transformations can affect the statistical properties
Perform a *post hoc* analysis of the data	Analyses done after the fact can be chosen to highlight or suppress various points

Avoiding Bias: ways to minimize the abuses

Recognizing the possible abuses of science can be an effective way to avoid being subjected to them. Beyond this, we can think of no single simple rule to follow that will minimize the opportunity for someone to violate the spirit of science and present misleading results -- there are countless ways to bias data. One strategy to avoid bias is to require detailed, explicit protocols. Another is to have the data gathered by and individual or company lacking a vested interest in the outcome. But even with these policies, there is no guarantee that deliberate biases can be weeded out. The following table gives a few pointers. All but the fourth item applies to minimizing bias in the conduct of the study, but 'anticipate vested interests' applies at all levels.

Ensuring Legitimate Science	
STRATEGY	**IMPACT**
Publish protocols in advance of the study	Prevents mid-course changes in response to results; enables requests for design modifications with little cost.
Publish the actual raw data	Enables an independent researcher to look objectively at the data, possible uncovering any attempts to obfuscate certain results
Specify evaluation criteria before obtaining results	Minimizes after-the-fact interpretation of data.
Anticipate vested interests	Bias in the conclusions of individuals, corporations, and political bodies can be predicted with remarkable accuracy by knowing their financial interests and their political and ideological leanings.
Consult trustworthy sources	Although no source may be completely free of bias, there are some sources that are usually trustworthy: NIH for medicine, Snopes for urban legends. You will no doubt develop your own trusted sources as you go forward
Peer review	Peer review of manuscripts submitted for publication is a common practice to guard against publishing bad science. In theory, the reviewers have no vested interest in the work and offer an unbiased appraisal of the work, identifying potential problems. However, peer review is only as good as the reviewers and the effort they are willing to provide. Inadequate review processes are common.

Drugs and Medicine

We take for granted an unlimited supply of medicinal drugs. If we get pneumonia, gonorrhea, HIV, or cancer, the drugs of choice are invariably available. They may not cure us, but whatever drugs we know about (that have been approved) are in abundant supply.

For the most part, this abundance of and reliance on drugs comes from public trust of health care. We don't imagine that our doctors try to prescribe us useless or unnecessary drugs (if anything, the patient often requests drugs when they are unnecessary). But in reality, many drugs ARE unnecessary, and some drugs are no better than cheaper alternatives. The Food and Drug Administration (FDA) is charged with approving new foods and drugs for the U.S. In 1992, it was approving about 20 new drugs a year but regarded only about 20% of those as true advances. So many drugs are no better than alternatives (many are obviously at least slightly worse than alternatives). And physicians often don't have the evidence to know which drugs are best.

The goals of consumers are in conflict with those of drug companies in some respects. The consumer wants drugs that are cost-effective safe with few side-effects. If two drugs are equally effective, we want the cheaper one. We may even not want the most effective drug if a cheaper one will do the trick. But the goals of any drug company are different:

- company sales, which may involve

- company reputation

- a successful treatment but not necessarily a cure

- low risk of liability claims (which may include drug safety and low side-effect)

It costs to hundreds of millions of dollars to get a drug approved by the FDA now. Much of the cost is in research and trials, but even FDA consideration itself costs millions. So it is not cheap. Most important is time, because the sooner a drug hits the market, the sooner the company reaps the benefits. So drug companies have strong incentives to market any product that is approved by the FDA -- once approved, the major costs of money (and time) have already been borne.

Of course, it does not behoove a company to market a harmful product -- liability costs can be quite high. But most products that pass all the hurdles of FDA approval can be regarded as harmless at worst. The drug company has a very strong incentive to market its approved products regardless of whether the consumer benefits or not. One of the most economically successful drugs ever was an ulcer medicine that reduced suffering. It did not cure ulcers but instead had to be taken as long as the patient had the ulcer. Research later found that most ulcers were caused by a bacterium and that treatment with antibiotics cured the ulcer. So the original ulcer treatment was based on a misunderstanding of the cause of ulcers.

There is no shortage of scientific method abuses in the drug industry. Publications of books like Overdosed America (J. Abramson 2004, HarperCollins Pub. Inc) and Should I be Tested for Cancer? (H. G. Welch 2004, U. California Press) provide a wealth of examples in which drug companies have gone to great lengths to subvert the scientific method in gaining FDA approval or to market drugs to physicians and the public. As an indication of the general problem of bias created by the conflict between corporate versus public goals, it was found in 2003 that commercially sponsored studies are 3.6-4 times more likely to favor the sponsor's product than studies without commercial funding. Also in 2003, another study found that, in high quality clinical trials, odds of recommending the new drug were 5 times greater in studies with commercial sponsorship than in those funded by non-profit organizations. Some flagrant examples follow.

Broaden the market: Something that has been shown to be effective in a narrow segment of the population gets recommended for a wider segment even when the evidence opposes its benefit to the wider segment or the benefit is at best extraordinarily expensive. Examples: defibrillators, statin drugs.

Ignore alternatives: Companies of all types do not benefit from sales of competing products. In medicine, it is often the case that new drugs/methods are no better than old ones, but the benefit of old methods/drugs are often neglected (when a company's patent for a product has expired, it has less incentive to defend that product against a newer alternative). Examples: the benefits of modest exercise and diet changes are often demonstrated to be more effective in reducing heart attack rates and even cancer rates than many drugs, but those alternatives are not mentioned to patients when being sold the drug. In a second example, a trial with Oxycontin (similar to heroin) used a control group with no pain killer. Not surprisingly, Oxycontin was found to be superior to no drug in reducing pain. Had the control group used an older painkiller, Oxycontin might not have been superior.

Comparisons confounded by dose differences: The antacid drug Nexium (whose patent was not expiring) was tested in trials against the chemically similar Prilosec (whose patent had expired). Rights to both drugs were owned by the same company, but with expiration of the Prilosec patent, sales of it would no longer be highly profitable. Nexium proved to be more effective in reducing acid reflux in this comparison trial. However, the dose of Nexium tested was twice that of Prilosec, even though Prilosec is commonly taken at the higher dose.

Testing the wrong age group: Many studies choose subjects who are younger than the expected users of the drug. For example, only 2.1% of all patients in studies of anti-inflammatory drugs were over 65, even though those over 65 are among the largest users of those drugs. Why? Drug side-effects are less likely to arise in younger patients. Examples: Aricept (for Alzheimer's) and cancer drugs.

Selective data release: Drug companies rely on researchers to conduct trials and, importantly, publish the results. Drug companies routinely restrict access to the data, so the researchers publishing the study don't see all the results, only the favorable ones.

Ghostwriters: The authors of a study are not necessarily the ones who write it. Companies will hire non-authors to write the first draft, which then gets passed off to the official authors for approval. Companies choose ghostwriters who know how to spin the study in the most favorable light.

Other tricks include:

- Drug companies have paid for university research on their products and have then blocked publication of unfavorable results and/or cut continued funding of the work when the results began to look bad.

- Pharmacy sales people routinely visit physicians at work, offering them free lunches, free samples of medicines, gifts, information to promote their products, and notepads and pens with company logos. (Next time you visit a physician, look around the inner rooms for evidence of company logos on charts, pens, pads, and so on.)

- To maintain their licenses, physicians are required to take courses in continuing medical education (CME). These courses are often sponsored and paid for by drug companies in exotic locations and with hand-picked speakers who provide favorable coverage of company products.

- Drug companies publish ads in medical journals that look and read like research articles. These ads promote products.

DNA

A second, well-documented case in which conflict is manifested is over DNA typing. These examples may not reflect current debate over DNA technology, but one should use them to appreciate the strong potential for conflict over any scientific issue in the legal system.

The rush to implement DNA typing in the U.S. criminal system was done before guidelines were set for proper DNA typing procedures. Consequently, there were varying levels of uncertainty in the use of these methods by law enforcement agencies and commercial labs. They were also reluctant to admit the uncertainty. The manifestation of conflict over DNA evidence was thus heated and surfaced in the popular press on several occasions. We introduce this material in a prospective manner - by first imagining how the prosecution, defense, and forensic lab can be expected to behave to achieve their goals in ways that are contrary to fair scientific procedure. You have already been exposed to the nature of the models and data in DNA typing, so now the issue is how the different legal parties deal with the problems in evaluation and ideal data.

If a case that uses DNA typing has come to trial, we can assume that the DNA results support the prosecution's case. There are thus three parties in conflict:

Prosecution <<< (in conflict with) >>> Defense <<< (in conflict with) >>> DNA lab

We can assume that the DNA lab's results support the Prosecution's case, or there would not be a trial, so the conflict will lie between the Defense and the other two agencies. Now consider how this conflict might be manifested.

I) What might the prosecution do to improve the chances of reaching its goals?

1. eliminate test procedures that benefit the suspect (eliminate standards; build a case of circumstantial evidence to shield criticism of the DNA fingerprint evidence).
2. harass or impede prior witnesses for the defense who might testify in the future.
3. keep a list of sympathetic expert witnesses
4. Maintain positive relationships with labs that have contributed to convictions in the past.

II) With respect to the errors and uncertainties of DNA evidence in specific cases:

5. argue that inconsistencies are plausible artifacts
6. fail to question any outcome in its favor

III) How is the defense likely to behave?

1. keep a list of sympathetic expert witnesses
2. emphasize all inconsistencies in the DNA analyses as evidence of innocence
3. question all assumptions, original data, calculations

IV) How is the lab likely to behave?

1. Produce results that enhance the goals of their economic benefactor, including

2. establish a reputation for a lack of indecisiveness; overstate case
3. defend its initial conclusions

Evidence from DNA cases:

The case histories available from the last 4-5 years of DNA forensics verify many of these expectations. In particular, DNA testing has omitted such basic elements as standards and blind procedures (I.1 above); the prosecution in the Castro case ignored inconsistencies in the evidence (I.5, I.6); the lab in the Castro case overstated the significance of a match and defended such practices as failing to include a male control for the male-specific probe (III.2, III.3). Defense and prosecution agencies definitely keep lists of sympathetic witnesses (I.3, II.1), and defense agencies indeed choose witnesses to challenge the nature of DNA evidence based on its (necessarily false) assumptions (II.3). And finally, harassment by the prosecution of experts who testify for the defense is well documented, both in the courtroom and outside (I.2). This harassment includes character assassination on the witness stand, implied threats to personal liberties for witnesses who were in the U.S. on visas, and contacts made to journal editors to prevent publication of papers submitted by the witness. Some of these cases have been described in the popular press, and others are known to us through contacts with our colleagues. These latter manifestations of conflict don't make sense in the context of a single trial, but they stem from the fact that networks exist in which prosecuting attorneys share information and parallel networks exist among defense attorneys. Expert witnesses are often used in multiple trials across the country, so any expert witness who is discouraged at the end of one trial will be less likely to participate in future trials, and conversely, an expert who does well in a trial may be more likely to participate in future trials.

The suggestions of harassment have even extended to scientists who merely publish criticisms of forensic applications of DNA typing. In the 1991-92 Christmas break, two papers were published in Science on opposites of the DNA fingerprinting conflict (Science 254: 1745-50, and 1735-39). At the same time, news items were also published in Science, Nature, The New York Times, and The Washington Post, in which the details of this conflict were aired in full detail. The authors of the paper opposing use of current DNA typing methods (Lewontin & Hartl) were phoned by a Justice Department official and allegedly threatened with retaliation (having their federal funding jeopardized); the official denied the threats but did not deny the phone call. The Lewontin-Hartl article had apparently been leaked in advance of publication, and an editor for Science contacted the head editor to have a rebuttal published. However, it turned out that the editor requesting the rebuttal owns a patent for DNA fingerprinting and stands to benefit financially by forensic use of DNA typing methods. The two authors chosen for the rebuttal had been funded by the FBI to work on DNA fingerprinting methods. So, there appears to have been some serious conflicts of interest at least on one side of the issue.

This treatment of conflict in DNA trials has omitted a 4th category of people whose goals may conflict with the agencies above: the expert witnesses themselves. The goals of expert witnesses may be varied, including monetary (the standard rate is $1000/day in court), notoriety, and philosophical (e.g., some people volunteer to assist the defense on a no-cost basis, merely to ensure a fair trial).