Misconception 5—The toxicology of synthetic chemicals is different from that of natural chemicals

It is often assumed that, because natural chemicals are part of human evolutionary history whereas synthetic chemicals are recent, the mechanisms that have evolved in animals to cope with the toxicity of natural chemicals will fail to protect against synthetic chemicals (Ames & al. 1987, Letters). This assumption is flawed for several reasons (Ames & al. 1996; Ames & al. 1990b; Gold & al. 1997b).

Natural defenses are general rather than specific for each chemical

Humans have many natural defenses that buffer against normal exposures to toxins (Ames & al. 1990b); these usually are general rather than tailored to each specific chemical. Thus, the defenses work against both natural and synthetic chemicals. Examples of general defenses include the continuous shedding of cells exposed to toxins—the surface layers of the mouth, esophagus, stomach, intestine, colon, skin, and lungs are discarded every few days; DNA repair enzymes, which repair DNA that has been damaged from many different sources; and detoxification enzymes of the liver and other organs, which generally target classes of toxins rather than individual toxins. That defenses are usually

general rather than specific for each chemical makes good evolutionary sense. The reason that predators of plants evolved general defenses presumably was to be prepared to counter a diverse and ever-changing array of plant toxins in an evolving world: a herbivore that had defenses against only a set of specific toxins would be at a great disadvantage in obtaining new food when favored foods became scarce or evolved new toxins.

Natural agents can be carcinogenic to humans

Various natural agents that have been present throughout vertebrate evolutionary history nevertheless cause cancer in vertebrates (Ames & al. 1990b; Gold & al. 1999; Gold & al. 1997a; Vainio & al. 1995). Mold toxins, such as aflatoxin, have been shown to cause cancer in rodents and other species, including humans (Gold & al. 1999). Despite their presence throughout evolution, many of the common elements are carcinogenic to humans at high doses (e.g., salts of cadmium, beryllium, nickel, chromium, and arsenic). Furthermore, ***epidemiological*** studies from various parts of the world show that certain natural chemicals in food may be carcinogenic risks to humans: for example, the chewing of betel nuts with tobacco is associated with oral cancer, and Chinese-style salted fish is associated with nasopharyngeal cancer (Gold & al. 2001a, http://monographs.iarc.fr/monoeval/crthgr01.html).

Humans have not had time to evolve a "toxic harmony" with all of the plants in their diet. The human diet has changed markedly in the last few thousand years. Indeed, very few of the plants that humans eat today (e.g. coffee, cocoa, tea, potatoes, tomatoes, corn, avocados, mangoes, olives, and kiwi fruit) would have been present in a hunter-gatherer's diet. Natural selection works far too slowly for humans to have evolved specific resistance to the food toxins in these relatively newly introduced plants.

Since no plot of land is free from attack by insects, plants need chemical defenses—either natural or synthetic—in order to survive. Thus, there is a trade-off between naturally occurring and synthetic pesticides. One consequence of disproportionate concern about residues from synthetic pesticides is that some plant breeders develop plants that are more insect-resistant because they are higher in natural toxins.

A case study illustrates the potential hazards of this approach to pest control. When a major grower introduced a new variety of highly insect-resistant celery into commerce, people who handled the celery developed rashes when they were subsequently exposed to sunlight. Some detective work found that the pest-resistant celery contained 6200 parts per billion (ppb) of carcinogenic (and mutagenic) psoralens instead of the 800 ppb present in common celery (Berkley & al. 1986; Gold & al. 1999; Gold & al. 1997b).