nanotechnology

no free lunch !

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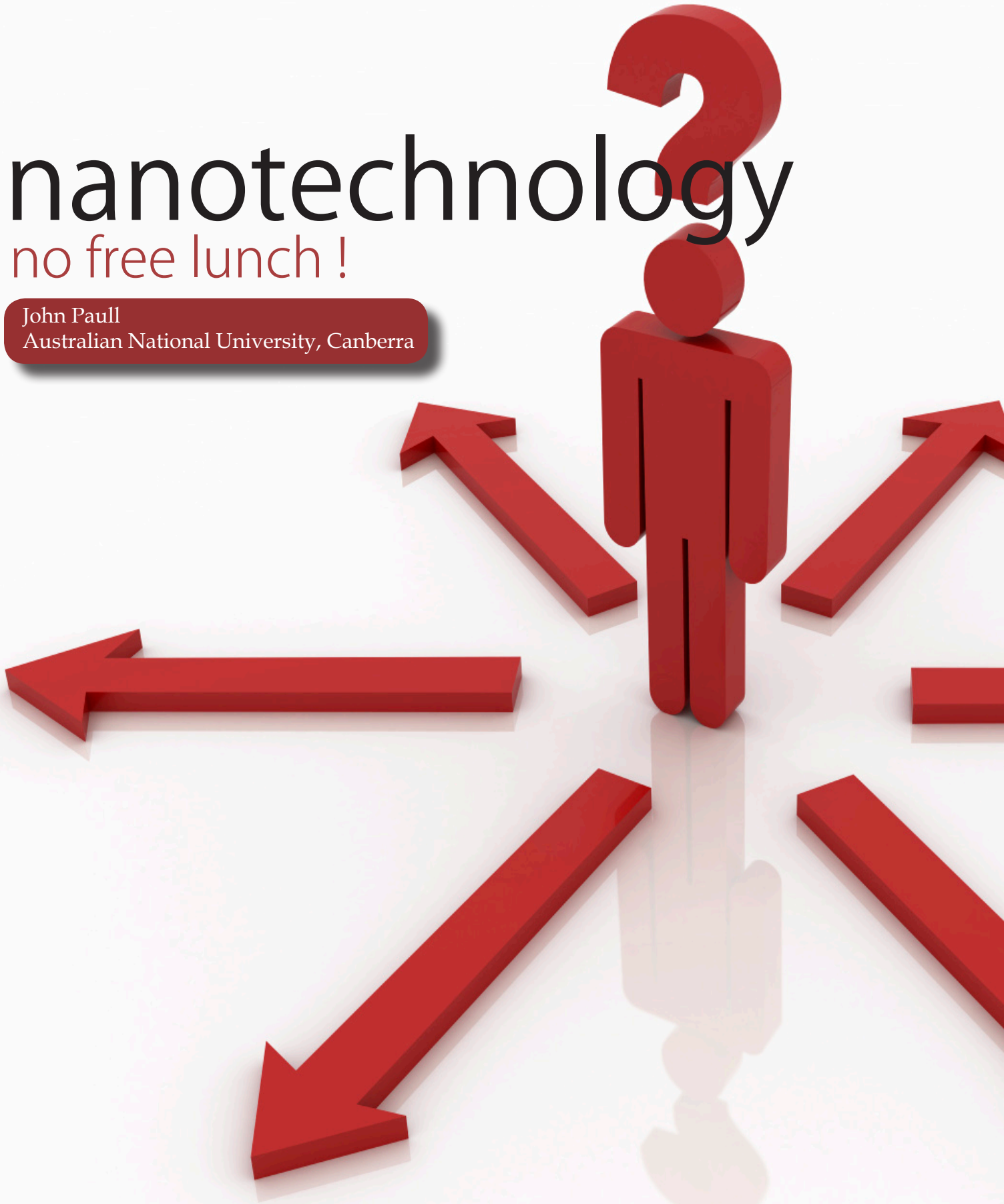


Food occupies a privileged position in all cultures and considerations.

Abstract

Nanotechnology is the new science and technology of the super small. Particles at the nano-scale, from one to one hundred billionths of a metre, exhibit novel properties. Nanotechnology is an active area of research and rapid commercialization. The food industry has been targeted as a potential recipient of this new technology and engineered nanoparticles are reportedly already in some super-market products. Nanotechnology is currently unregulated, and there are no requirements for mandatory labelling, this leaves consumers unprotected and uninformed. Consumers are largely unaware of nanotechnology, expect labelling on nano-products, are unclear of the cost/benefit balance, and express an unwillingness to purchase nanofood. The asymmetric information status of nanotechnology, together with its undetermined safety, raises issues, opportunities, and risks for food manufacturers and retailers.

Why Nanotechnology?

Eric Drexler introduced his vision for nanotechnology in his 1986 book Engines of Creation. At that time he asked: "What is possible, what is achievable, and what is desirable?" (Drexler, 1986, p.39). In the past decade, nanotechnology has grown into a billion dollar research enterprise with an explicit aim of rapid commercial deployment (Roco, 2007) (Fig. 1). The definition of nanotechnology offered by the US National Nanotechnology Initiative (NNI) is: "the understanding and control of matter at dimensions of roughly 1 to 100 nanometers (a nanometer is one-billionth of a meter), where unique phenomena enable novel applications"(Marburger, 2007, p.3). The commercial interest in nanotechnology derives particularly from the new properties that nanoscale materials may exhibit, which may be unexpected and unpredictable as scale effects, and that are not exhibited by the same material in bulk.

For the purposes of the present discussion I adopt the NNI specification that nanotechnology is the creating of engineered nanoparticles in the size range

of 1 to 100 nanometres (i.e. 1 nm to 100 nm; 10^{-9} m to 10^{-7} m). The resolution of light microscopes is limited to 200 nm, and thus nanoparticles are beyond the scope of light microscopy. An electron microscope can resolve down to 0.1 nm (Alberts, et al., 1989). Nanoparticles are thus beyond the detection of almost all consumers.

Nanotechnology offers the potential to give manufacturers 'more bang for the buck'. This prospect of achieving more with less is an attractive corporate proposition. As the size of particles is reduced, the relative surface-area is increased, and because reactivity is a function of the surface-area, this can lead to achieving the same amount of reactivity and/or bioactivity using a lesser quantity of agent. For a given quantity of material, if the linear dimensions of particles are decreased by a factor of x, then the total surface area is increased by a factor of x (Paull & Lyons, 2008).

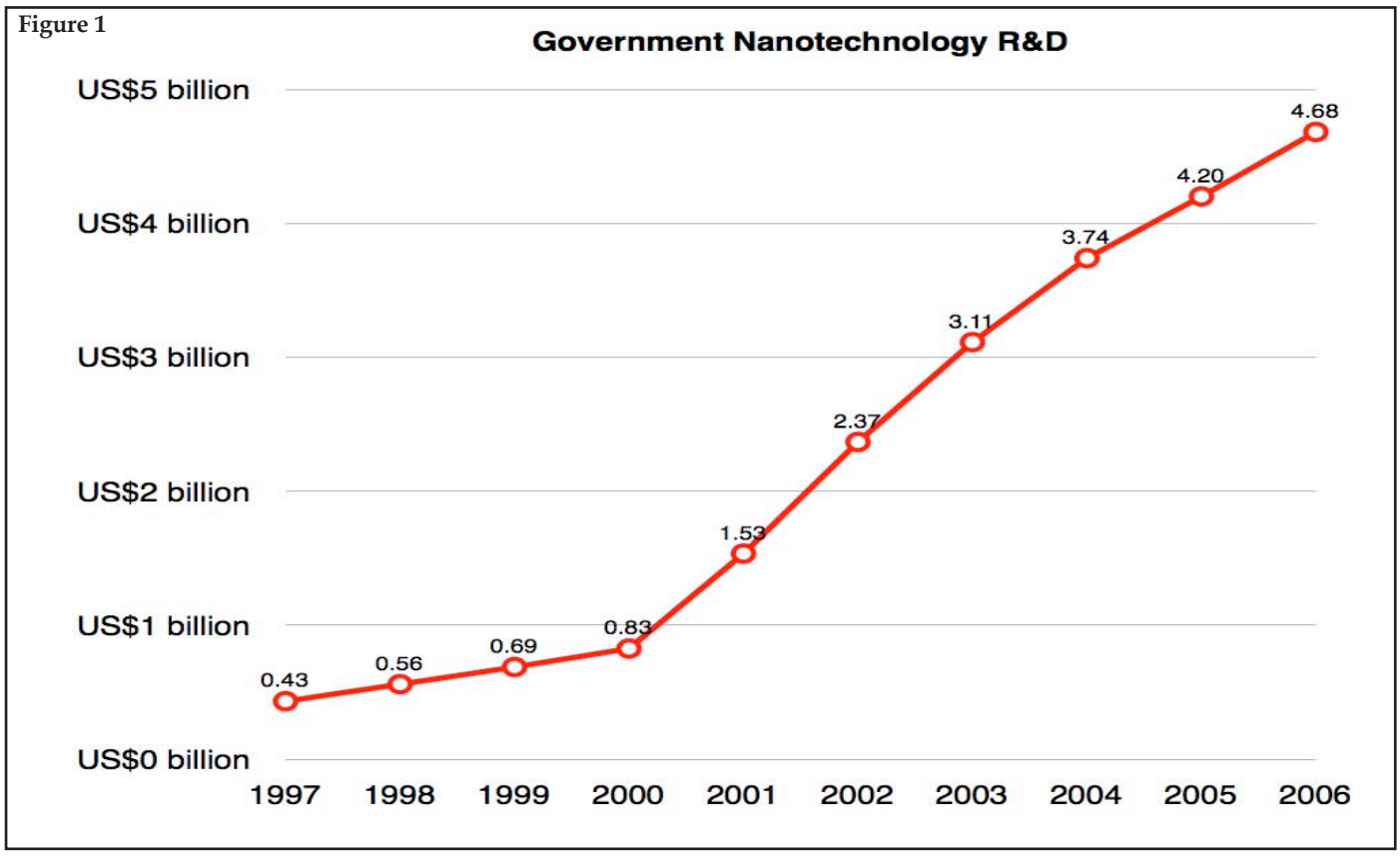
Public Awareness

The public awareness of nanotechnology is low. In a survey, 71% of US consumers (N=1014) stated they knew little or nothing about nanotechnology (HRA, 2007), and for Australian consumers (N=1100) the corresponding figure was 77% (MARS, 2008) (Fig. 2).

When consumers were asked their views of the risk versus benefit of this new technology there was a spread of opinions. More than half of the US consumers stated that they "didn't know" (HRA, 2007) (Fig. 3). More than half of Australian consumers expressed the view that the benefits outweighed the risks (MARS, 2008), despite the great majority of them admitting to knowing little or nothing about the subject.

A previous study (MARS, 2007) asked Australian

Figure 1



Estimated annual government nanotechnology R&D expenditures; USA, EU, Japan and others (Data source: Roco, 2007).

consumers (N=1000) their views on nano-labelling and nanotechnology side-effects. The results were that 71% advocated mandatory labelling, and 63% expressed concern for side effects (Fig. 4).

Only 7% of US consumers would willingly purchase food "enhanced with nanotechnology", 30% stated that they would not purchase such food, and 63% appeared to have an open mind on the subject stating that they would need more information (Fig. 5).

The question asked was biased in stating that the food was "enhanced with nanotechnology" rather than, say, "modified with" or "contaminated with nanotechnology".

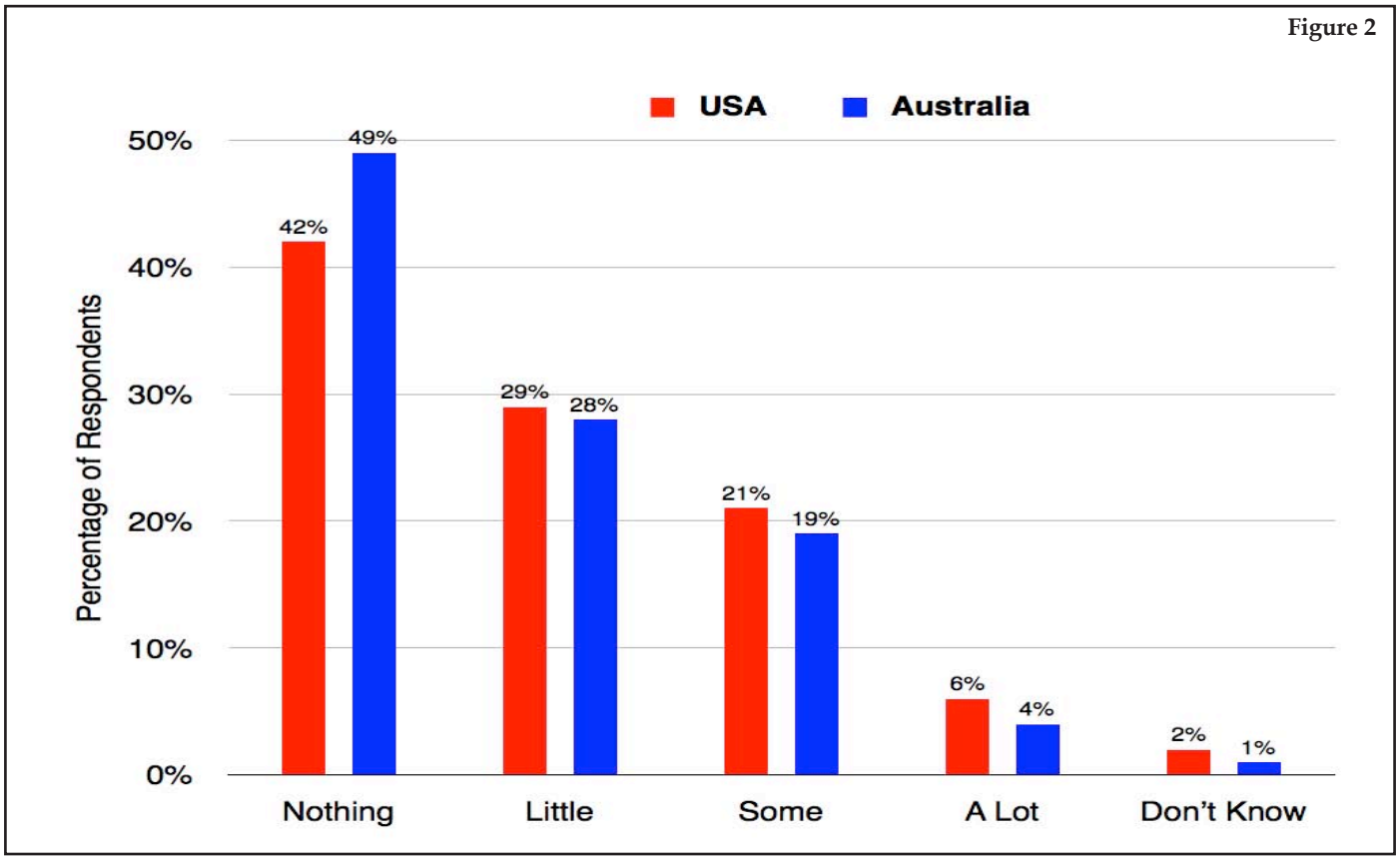
The conclusion can be drawn that the government is out of step with community opinion, by neither regulating nanotechnology nor requiring nano-labelling.

Nanotechnology and Food

Consumer products incorporating engineered nanoparticles are already on the market. An inventory of consumer products incorporating nanotechnology identified 580 nano-products, and classified them into eight categories (WWICS, 2007; Fig. 6). Of the 580 nano-products, 12% were classified as 'Home and Garden' and the largest category was 'Health and Fitness' which accounted for 61% of the total (Fig. 6).

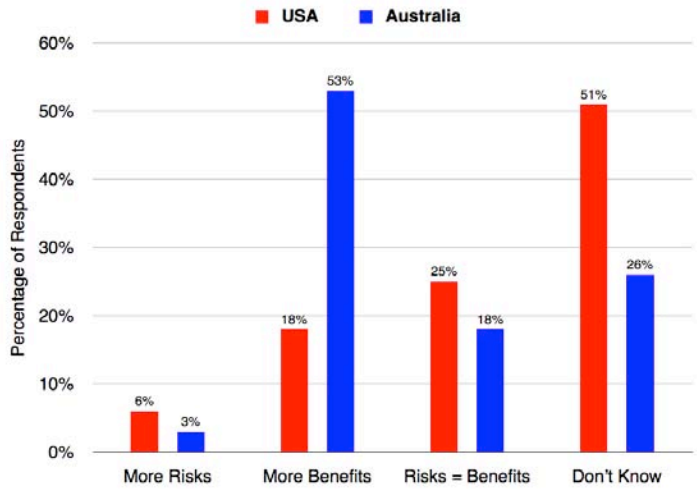
The 'Food and Beverage' category accounted for 11% of the total (WWICS, 2007; Fig. 6). These products were further subdivided as: 'Food'; 'Cooking'; 'Storage'; and 'Supplements' (Fig.7). The three nano-food products were: a canola oil, a chocolate slim shake drink, and a nanonized beverage, 'Nanotea'. The nano-food, 'Slim Shake Chocolate', is advertised as being: "Low in fat and calories"; "No artificial

Figure 2



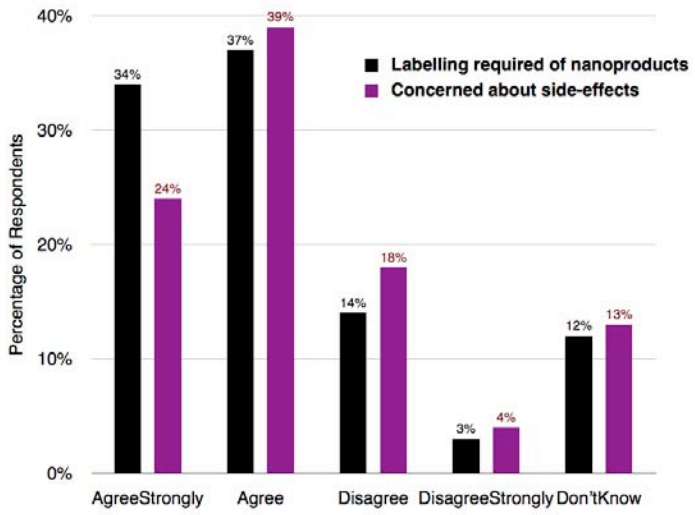
Public awareness of nanotechnology in the USA and Australia is low. US respondents were asked "Have you heard much about nanotechnology?" (Data sources: HRA, 2007; MARS, 2008)

Figure 3



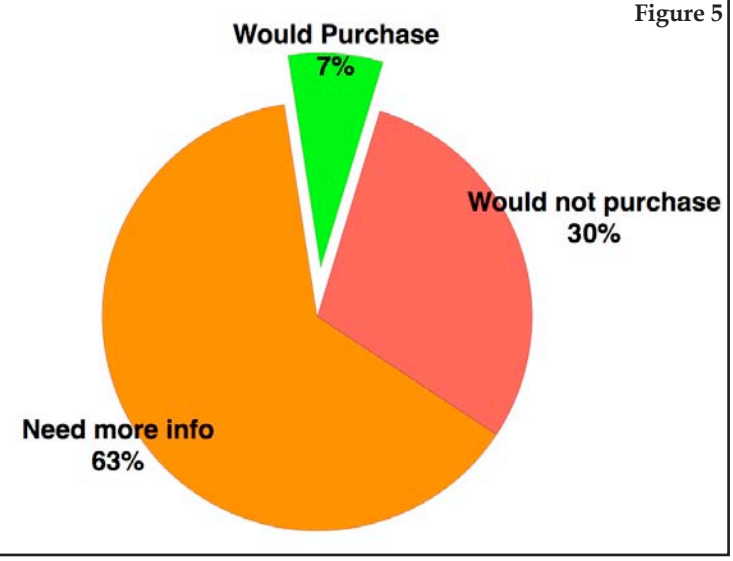
US and Australian respondent's impressions of the risks versus the benefits of nanotechnology; USA (N = 1014) & Australia (N=1100) (Data sources: HRA, 2007; MARS, 2008)

Figure 4



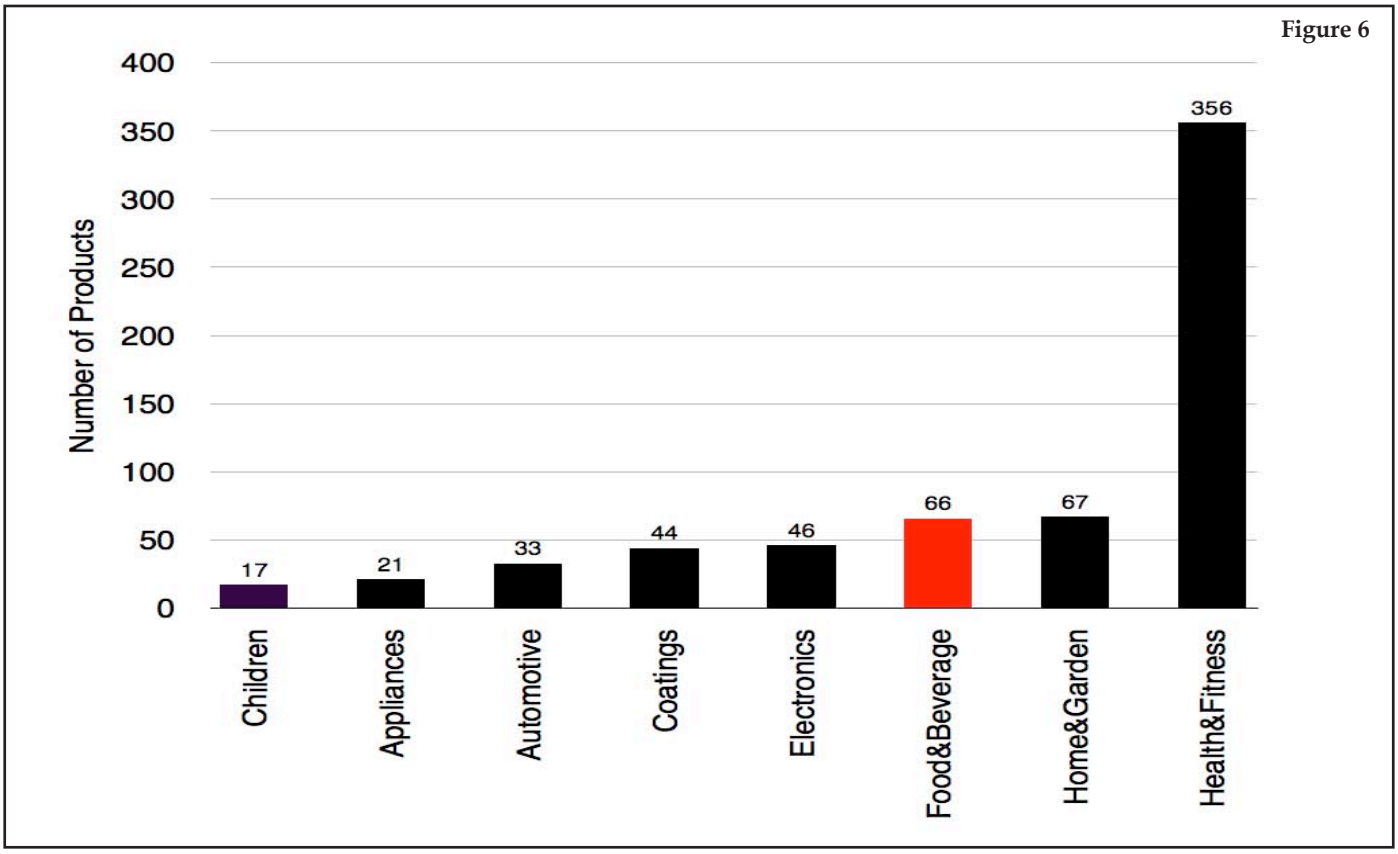
Australian consumers support labelling of nanoproducts and are concerned about side effects (N=1000) (Data source: MARS, 2007)

Figure 5



Few US consumers would purchase "food enhanced with nanotechnology" (N = 1014) (Data source: HRA, 2007)

Figure 6



Products incorporating nanotechnology currently in the market (N = 580). Note: some products are attributed to more than one category (Data source: WWICS, 2007)

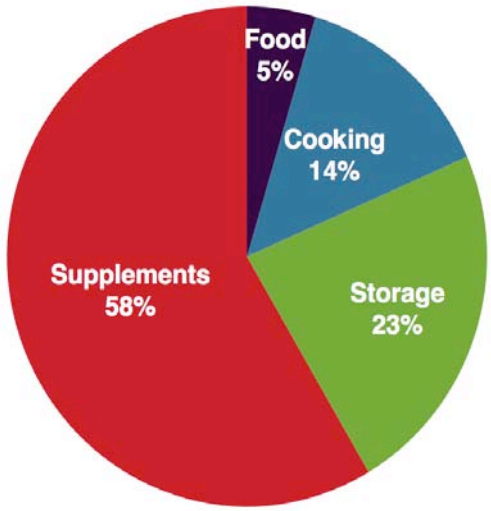
sweeteners"; "Tastes delicious"; and containing "NanoClusters". These so-called NanoClusters are claimed to be: "tiny particles, 100,000th the size of a single grain of sand, and they are designed to carry nutrition into your cells" (O'Connor, 2006).

The 'Cooking' category includes: anti-bacterial utensils; cutlery; chop sticks; and cookware. 'Storage' includes: plastic beer bottles; 'Miracle Food Storage' plastic bags and containers; plastic food wrap; and a baby's mug and milk bottle. A 'Daewoo' refrigerator advertisement claimed that: "Nano silver presents strong disinfection, deodorant and storage power. It also maintains balance of hormone within our body and intercepts electromagnetic waves significantly" (WWICS, 2007)

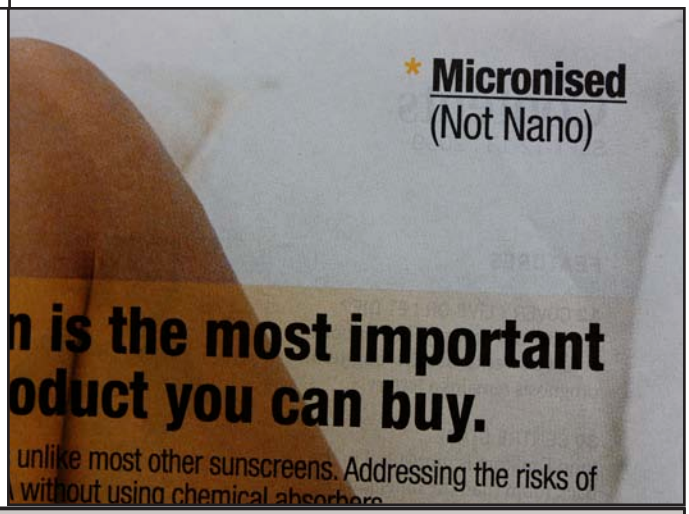
Miller & Senjen (2008, p.3) identified 104 agriculture and food-chain products, "now on sale internationally", that incorporate nanotechnology. They state that: "we believe this to be just a small fraction of the total number of products now available worldwide". Major food and beverage corporations, including Nestle, Kraft, Unilever, PepsiCo, General Mills, Campbell Soup, McCain, and Goodman Fielder are investing in nanotechnology (ETC Group, 2004, p.63). According to Keller and Heckman (2009): "Food and food packaging have been at the forefront of nanotechnology innovation".

Paull & Lyons (2008) identify three routes for nanoparticles to enter the food stream (Table 1). The intentional introduction of nanotechnology into food products includes nano food-processing additives and nano agricultural inputs, including pesticides. The incidental introduction of nanoparticles to the food stream includes deciduous particles from nanonized surface treatments including paint, from filtration devices, and from nano-treated clothing. Adventitious nano-contamination includes that from airborne and water borne particle-drift from off-site sources.

Figure 7



Distribution of nanotechnology products classified as 'Food and Beverage' (N= 66) (Data source: WWICS, 2007)



An advertisement for a skin care product distances itself from nanotechnology by declaring: "Not Nano"(Invisible Zinc, 2009, p.13)

Table 1

sources of nano in food	examples
Adventitious	Nano-pollution from: airborne, rain-borne, water-borne nanoparticle-drift from off-farm and/or off-site.
Incidental	Nano-pollution from: nanonized packaging; surface coatings including paint - in packaging, sorting, storage, distribution, sales areas; utensils; packaging equipment; transport equipment; filtration equipment; clothing.
Intentional	Nanoparticles from: nanonized production inputs; food processing additives; agricultural foliar or systemic sprays.

Taxonomy of potential sources of nano-contamination of food (Table after: Paull & Lyons, 2008)

Consumers remain in ignorance of their consumption of nanoparticles, unless the addition is intentionally added by the manufacturer, and nano-labelling is perceived to be a marketing advantage. In the absence of nano-regulation, there is generally little or no incentive for manufacturers to guard against 'adventitious' and 'incidental' introductions of nanoparticles.

Corporate Risk

The push to nanonize food is driven by commercial considerations, there is no corresponding pull from consumers. Nanotechnology is not setting out to meet any pent-up demand for nano-products or nano-food. As recent consumer surveys demonstrate, there is consumer doubt over the benefits, concern over potential side-effects, and resistance to purchasing nanofood. No government has regulated nanotechnology, food manufacturers are operating in a regulatory vacuum, both nationally and internationally (Bowman & Hodge, 2007; Breggin & Pendergrass, 2007; Catanzareti, 2008; ETC Group, 2004; Miller & Senjen, 2008; Seear, Petersen, & Bowman, 2009). Only the organic food standards of a few countries, including Australia (OIECC, 2009) and the UK (Soil Association, 2008), have excluded engineered nanoparticles from their standard (engineered nanoparticles are excluded as distinct from what may be 'naturally' occurring nanoparticles). The argument of "substantial equivalence" can be invoked for nanotechnology as it has been for genetically modified (GM) food (Paull, 2008). Substantial equivalence is a ploy whereby innovations are presented to patent offices as novel and warranting patent protection, while at the same time the material is presented to environmental regulators as the same or 'substantially equivalent' to existing material, and hence warrants no new regulatory oversight.

There is an opportunity, as well as a risk, in the application of nanotechnology to food. Food occupies a privileged position in all cultures and considerations. Right now, with no proven safety metrics for nanoparticles added to food, the precautionary approach for food manufacturers would be to actively exclude nanoparticles from the production chain. Engineered nanoparticles exhibit novel properties and because of their size they can breach biological 'barriers to entry'. The health implications of nanoparticles are unknown, the ramifications may be profound, and only a lengthy and extensive research effort can assess the safety implications with any certainty (EPA, 2007) (Table 2). For those manufacturers actively pursuing nanofood the question is, where is the risk to be carried? Are the consumers to carry the risk? Do any manufacturers carry insurance should the technology be found to not only be surprising, but to be surprisingly deleterious to workers, consumers and/or the environment? Is there any insurance company anywhere that will insure the nanotechnology risk?

Table 2

EPA's nanotechnology health issues
" … nanoparticle toxicity is complex and multifactorial, potentially being regulated by a variety of physiochemical properties such as size, chemical composition, and shape, as well as surface properties such as charge, area and reactivity. As the size of particles decreases, a resulting larger surface-to-volume ratio per unit weight for nanoparticles correlates with increased toxicity as compared with bulk material toxicity. Also as a result of their smaller size, nanoparticles may pass into cells directly through cell membranes or penetrate the skin and distribute throughout the body once translocated to the circulatory system. While the effects of shape on toxicity of nanoparticles appears unclear, the results of a recent in vitro cytotoxicity study appear to suggest that single-wall carbon nanotubes are more toxic than multi-wall carbon nanotubes. Therefore, with respect to nanoparticles, there is concern for systemic effects (e.g. target organs, cardiovascular, and neurological toxicities) in addition to portal-of-entry (e.g. lung, skin, intestine) toxicity".

The US Nanotechnology White Paper (EPA, 2007, p.78) acknowledges the uncertainties surrounding nanotechnology and reinforces the doubts of consumers

Cadbury has recently demonstrated that changing a recipe, in their case changing from traditional dairy ingredients of chocolate to "vegetable fat", created a massive consumer backlash and the recipe promptly reverted to the original, or so we were told (The Mercury, 2009). In the process the consumers who not only wanted the dairy recipe back, but also wanted a company that they could trust, may not all have reverted their loyalty.

Kraft, in an ill-considered move, demonstrated the same issue by messing with Australia's favourite breakfast spread, Vegemite, and concocted a derived soft spread called iSnack2.0 (BBC, 2009). An immediate consumer backlash saw that ill-fated concoction withdrawn from the market within weeks of its launch, but just how enduring was the damage to Kraft's reputation remains undetermined.

Conclusion

Drexler asked, of nanotechnology, what is possible, what is achievable, and what is desirable? For nanofood there is no evidence that nanoparticles in food are 'desired' by any consumer.

For food processors, nanofood is certainly 'possible' and it is already 'achievable'. But the question remains for food manufacturers: "is the nanotechnology game worth the candle?" Do the potential returns outweigh the costs and risks? The potential risks include those to reputation, to food workers, to consumers, to the environment, and ultimately to the corporate bottom line. Nanotechnology offers no 'free lunch'.

For food manufacturers proceeding with a nano strategy, for whatever reason, there is the question of transparency. Consumers are in a disadvantaged position within an asymmetric information regime. Manufacturers declare what they deem to be self-advantageous.

To remedy this information asymmetry, the minimum requirement from food manufacturers is to provide a clear declaration on the label of any nanofood to the effect that: "This product contains engineered nanoparticles".

For others there is the option of declaring "No Nano". Such an approach has recently been adopted by a sunscreen company (Invisible Zinc, 2009), and the organic food sector has made a start on a certified exclusion of engineered nanoparticles from organic food.

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