WEEKLY | NEWS IDEAS INNOVATION

THE BEST JOBS IN CANADA

NewScientist

23 September 2006

Nothing is forever

Not even the laws of nature

Fuels gold

Empty promises of the biofuel revolution

SPECIAL REPORT

Search for the perfect diet

Eat your way to a healthy body

Foods to make you smart

£2.70 US$4.95 No2570

THE GOOD THE FAD AND THE UNHEALTHY

The road to the perfectly balanced diet is littered with discarded trends and mixed messages. So where does the truth lie? New Scientist brings you an in-depth look at the facts, and explodes a few myths along the way. By **Bijal Trivedi**

YOU know how it is. You watch your diet. You try to eat the right stuff, in the right amounts. You keep an eye on the latest news about diet and health. It's tough enough at the best of times, yet for some reason the advice seems to keep on changing, so you end up not knowing whether you are doing the right thing or eating yourself into an early grave.

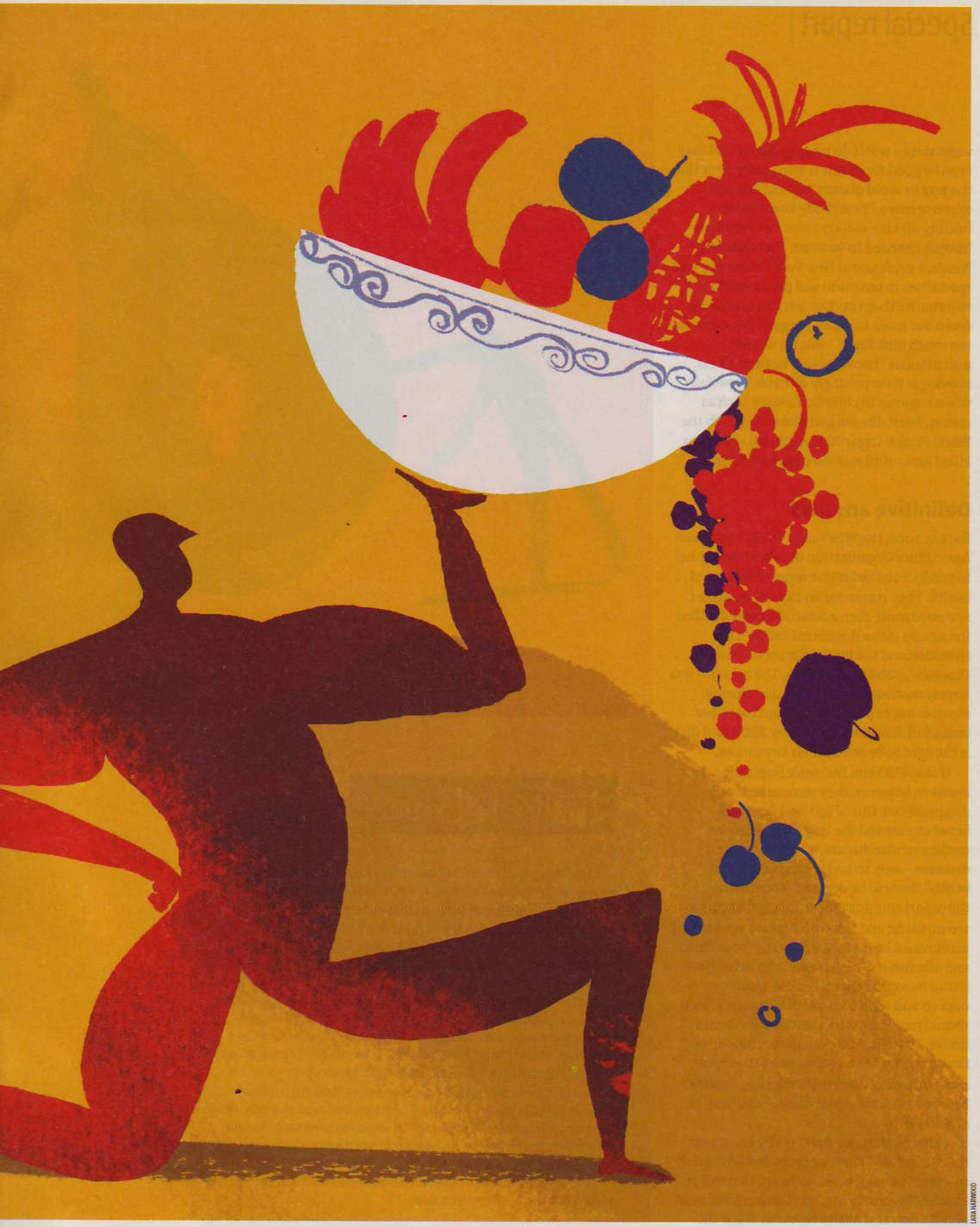
Take dietary fibre. You could be forgiven for thinking that eating lots of fibre is a good idea: according to almost every piece of official advice, it helps prevent colon cancer. Yet last year a large study published in *The Journal of the American Medical Association* concluded that you might as well not bother.

And it's not just fibre. In the past few months the supposedly rock-solid benefits of eating a low-fat diet have been called into question by one of the biggest nutritional studies ever conducted. Another study debunked the benefits of oily fish. Add to that the endless flip-flopping over particular foods and nutrients – carbs, fats, eggs, nuts – and it's no wonder we're all finding it so hard to know what to eat.

Why is it so difficult to nail down what constitutes a healthy diet? Why, despite hundreds of studies over many decades, do we still not have a sure-fire recipe for good health? The answer, it turns out, is that when it comes to humans and food, getting rock-solid answers is like squeezing juice from a kumquat.

The idea that your diet can improve your health is an ancient one. The mantra "you are what you eat" may have a modern ring but it comes from Ayurvedic medicine more than 5000 years old. Around 400 BC the Greek physician Hippocrates made the link explicit when he wrote, "Let food be your medicine and medicine be your food."

In the west, the relationship between diet and health has come under decades of intense scientific investigation. As a result it is now possible to say with some certainty that most of the orthodox advice – eating less fat, salt and sugar and more whole grains, fruit and ▶



LARA HARWOOD

vegetables – won't do you any harm, and may even be good for you. It is also pretty clear that the way to avoid obesity is to eat less and exercise more. "Everybody knows what a healthy diet is – dietary recommendations haven't changed in 50 years," says Marion Nestle, a professor at New York University who specialises in nutrition and public health. "I summarise them saying: 'eat less and move more, eat more fruits and vegetables, don't eat too much junk food.'" But for all that nutritionists "know" what a healthy diet is, proving it is surprisingly difficult, especially when it comes to chronic diseases such as cancer, heart disease and diabetes, which the World Health Organization (WHO) estimates killed around 26 million people in 2005.

Definitive answers

Back in 2002, the WHO and the UN's Food and Agriculture Organization decided it was time to produce the definitive report on diet and health. They convened an expert panel that reviewed more than 400 studies and distilled the results into a document called "Diet, Nutrition and the Prevention of Chronic Diseases", published in 2003. The exercise was largely motivated by the fact that chronic diseases are expected to account for 75 per cent of all deaths worldwide by 2020, and diet is thought to be one of their key causes.

If the WHO and FAO were hoping for clear answers, however, they were to be sorely disappointed. Out of 140 possible links between diet and the "big four" – cancer, cardiovascular disease, osteoporosis and diabetes – only 10 had enough evidence behind them to be deemed "convincing". All the report could say for sure was that eating too much fat and salt will increase your risk of cardiovascular disease while fruit, vegetables and oily fish reduce it; salted fish raises your risk of nasopharyngeal cancer; and if you're over 50 and want to avoid osteoporosis, you should increase your calcium and vitamin D intake. That's it. And even these "conclusive" findings have been eroded since the report came out, with studies questioning the links between cardiovascular disease and both fat and oily fish.

Perhaps, then, we don't really know that much after all. "There are very few [diseases] where we can say, hand on heart, that this is absolutely convincing," says Susan Jebb, head of nutrition and health research at the UK

Trans fats

Five years ago almost no one had heard of trans fats. Today they are public enemy number one. Do they deserve their reputation or is it just a fad?

Trans fats are the darling of the food industry because they are highly resistant to rancidity and so extend the shelf life of bread, snacks, oils, baked products, milk substitutes and just about any processed food. Restaurants love them because oils with trans fats can be repeatedly heated and cooled without breaking down.

In the eyes of nutrition researchers, however, trans fats are universally regarded as bad news. There is good evidence that they cause clogged arteries and heart attacks, raise your LDL cholesterol (the bad form), and lower your HDL cholesterol (the good one). Some researchers even believe high quantities of trans fats hinder learning and memory.

This year, to encourage food makers to remove these fats from their products in the US, the Food and Drug Administration ruled that trans fats be listed on package labels. As anti-trans-fat sentiment takes hold, lawsuits against fast-food companies are on the rise, and the city of Chicago is even debating a ban on oils containing trans fat in restaurants.

In 2002 the US National Academy of Sciences concluded that the only safe amount of trans fat in the diet is zero.

LARA HARWOOD

You may as well eat sugar as baguettes, but not all carb-rich foods are bad news

Medical Research Council's Human Nutrition Research centre in Cambridge.

Why are there so few answers? One major source of confusion is that nutritional research often focuses on single dietary components – nutrients isolated from food, or foods abstracted from their diet and lifestyle context. This nutrient-by-nutrient analysis is important because it forms the basis of nutritional advice, such as the US Department of Agriculture's food pyramid (see Graphic, page 47). Yet any single nutrient isn't going to make a huge difference to your health when you need at least 50, according to Nestle.

Even more confusing is that studies of this kind often get hyped up by the media – especially if the results go against received wisdom, or tap into a current fad such as low-carb diets, trans fats or water. "Each little jigsaw piece is picked up by the media and made into a message," says Shirley Beresford, an epidemiologist at the University of Washington in Seattle. "Maybe we shouldn't always turn our scientific findings into a ▶

Carbohydrates

The past few years have been a roller-coaster ride for carbohydrates. Once considered the cornerstone of a healthy diet – standard dietary advice recommends six to 11 servings a day, more than any other food group – carbohydrates took a pounding during the recent low-carb diet craze. Yet this year the much-maligned carb is back in favour: results from the Women's Health Initiative, the largest long-term dietary intervention experiment ever conducted, revealed that a diet high in some types of carbohydrate doesn't cause you to get fat.

So are carbs good or bad? There's no easy answer, because not all carbs are created equal.

Carbohydrates consist entirely of chains of sugar molecules; what differs is the type of sugar, how many there are, and how they are linked together. Carbs basically come in two flavours: simple and complex, depending on the number of sugars in them. Simple carbohydrates contain just one or two sugar molecules, such as glucose or fructose, the sugar found in fruit. Table sugar, sucrose, is a simple sugar made up of one glucose and one fructose molecule. In contrast, complex carbohydrates contain from three to hundreds of sugar units joined together. Most of the complex carbs in our diet are starches, long chains of glucose molecules linked together in a branching chain.

Once in the gut, digestive enzymes break complex carbs into single glucose units that can then pass through the intestinal wall directly into the bloodstream. When too much glucose hits the bloodstream at once, however, it overwhelms the body's ability to utilise it and is stored as fat. There is also some evidence that this "glucose spike" is linked with cardiovascular disease and type 2 diabetes, but the jury is still out. As a rule of thumb, the more complex the carb, the better it is for you because the slower it will release its sugars.

It's not just about sticking to complex carbs though. Fibre, the indigestible material found in fruit, vegetables and whole grains, slows the absorption of sugars from the intestine and prevents the glucose spike. This is why healthier diets are not only low in refined carbs such as sugar, white flour and alcohol, they also contain plenty of fibre.

Exactly how do you figure out which carb foods are good? One pointer is the glycaemic index. The GI is a way of comparing how rapidly carbohydrates affect blood glucose levels compared with pure glucose, which is given a GI of 100. Foods with a high GI (above 70), such as peeled, boiled potatoes (89) or baguettes (95), hit the bloodstream fast and cause spikes in blood glucose. Foods with a low or moderate GI (55-70) like wholegrain breads release their glucose more slowly.

GI can be deceptive, though, because it doesn't tell you the absolute amount of carbohydrate in the food. A boiled carrot has a high GI, but contains so little sugar that it has almost no impact on blood sugar – it has a low "glycaemic load". Fruits, vegetables, lean meat and grains all have a low glycaemic load. Many nutritionists now consider the glycaemic load to be the measure that matters.

PAUL GAFFEN/ALAMY

"Diet alone is not going to reduce your risk of getting cancer"

message. Then people would not have the impression that nutritional advice changes every day of the week."

These problems are only amplified by the fact that humans are such difficult research subjects. There are basically three types of experiment you can do, each with pros and cons. The most stringent are metabolic studies, where researchers have complete control over participants' diets for days or weeks at a time. These are useful for determining whether a certain nutrient, food or diet affects "biomarkers", such as cholesterol level, that are believed to be linked with certain diseases. The catch is that these trials don't mimic real life and generally do not last long enough to probe realistic links between diet and health.

At the other end of the spectrum are observational studies, where researchers recruit a big group of healthy people and record what they eat for months or years while monitoring their health. This is the most common type of study, but is bedevilled by confounding factors – exercise, smoking, alcohol intake and myriad other variables – which statisticians must account for before they can work out what the results mean.

In the middle is the gold standard: the randomised intervention trial. In these studies one group is asked to change some aspect of their diet – eat less fat, say, or more fruit – for months or years on end, while the other group is told to carry on as normal. At the end, the researchers can compare the number of cases of, say, colon cancer in the two groups to see whether the change in diet has had any effect.

"These trials are considered the most valid," says Beresford. "If the question is 'does this type of dietary change result in this type of health benefit?' then this is the best trial to answer the question, but they are very expensive and very rare."

What's more, intervention studies are far from easy to get right. The main problem is compliance: initially the intervention subjects are conscientious about their regime, but as the study progresses they tend to slip. Control subjects, meanwhile, are free to change their diets voluntarily in response to health messages. The result is gradual convergence of the two groups. And that creates a dilemma: to get statistically significant results, studies must extend for as long as possible, yet the longer the study goes on the less difference there is between the two groups.

"In so many cases the ideal randomised trial is impossible to conduct," says Walter Willett, a professor of epidemiology and nutrition at Harvard School of Public Health.

Supersized study

For an example of the problems, look no further than the Women's Health Initiative, a long-term study of postmenopausal women that included the largest long-term dietary intervention trial ever conducted. This study recruited almost 49,000 women to prove

Fruit & veg

Here's another food group where the advice is easy to trot out but harder to follow. According to long-standing advice, a healthy diet includes four servings of fruit and five of vegetables each day.

But how much is a serving, and where does the advice come from?

The first part is simple: one serving is just over 100 grams, or about half a cup. A regular banana or orange will usually take care of two of the fruit servings. So hitting the target should be easy.

The second question is harder. The advice to eat lots of fruit and vegetables is certainly based on sound science. According to the World Health Organization there is convincing evidence that it lowers the risk of heart disease and probably cancers too. It also seems to promote better mental health.

So how do we know that nine servings is right? The serving sizes are based on "dietary reference intakes" (DRIs) – basically the quantity of essential nutrients needed to prevent deficiencies such as scurvy and decrease the risk of chronic diseases. These are calculated by bodies such as the US National Academy of Sciences, nutrient by nutrient, then converted into overall dietary advice such as the food pyramid.

Critics say that the NAS sets those DRIs at a level that would meet the nutrient needs of 98 per cent of the population, whereas most people can meet their needs at much lower intakes.

It's worth bearing in mind that nutritionally speaking, unprocessed frozen fruits and vegetables are almost as good as fresh ones. But that's less true of short cuts such as fruit juice, dried fruits or yoghurts with fruit pieces in them. As a general rule the more processed the fruit, the less it counts.

once and for all that a low-fat diet lowers the risk of breast cancer, colon cancer and heart disease. At the start of the trial the women were divided into two groups; one was coached intensively to reduce their fat intake to 20 per cent of total calories and increase their daily servings of fruits and vegetables to five and whole grains to six. The trial went on for eight years.

Everyone expected the study to confirm what they already "knew", but when the researchers crunched the numbers they got a nasty surprise. Women who changed their diets had fewer cases of heart disease and cancer, sure, but the differences were too small to be ruled out as chance events.

"I was surprised by the results initially," says Beresford, the lead author of one of three papers announcing the results (*The Journal of the American Medical Association*, vol 295, p 629, p 643 and p 655). "Perhaps if you had bigger numbers or gone on for longer, it might have become significant."

RICHARD HAMILTON-SMITH/CORBIS

Definitely good for you, but how much is a serving and do you really need five?

Water

We all know the advice: drink at least eight glasses a day. That's about 2 litres, which is a lot to swallow down. Do you really need that much?

The human body is about 60 per cent water, but you lose water all the time and it must be replaced. The US Institute of Medicine sets the general replacement level at approximately 2.7 litres of water a day for women and 3.7 litres for men. Set against that, eight glasses seems low.

However, the institute also points out that all drinks count. Tea, coffee, juice, smoothies, sodas and even alcoholic drinks all contribute. Fruits and vegetables, which are mostly water, also add to the tally.

The bottom line is that most of us have no problem replacing lost fluid and there's no need to be at the water dispenser all day long. The best advice, again from the IoM, is that your body will tell you when you need water. In other words, drink when you are thirsty.

There are also reasons to believe that the design of the study was flawed. The main problem, says Willett, was that as so often, the intervention group fell short of its targets. They did increase their fruit and vegetable intake from 3.6 to 4.9 servings a day, but fat consumption only fell from 38 per cent to 29 per cent of total energy intake, and servings of grains remained essentially unchanged at 4.5.

Intriguingly though, a closer look at the data reveals that women who were able to reduce their their fat consumption the most – by 12 per cent on average – saw their breast cancer risk fall significantly. Similarly, those women who dramatically lowered their intake of saturated or trans fats had significantly lower risk of heart disease. "We have to be honest and say that it's not proven, but the trends in all the papers were positive. There's not a shred of evidence that anyone was any worse," says Jebb.

It's partly a problem of shifting goalposts. An intervention designed to study diet and heart disease should have focused not on total fat but on saturated fats, cholesterol and trans fats, says Linda Van Horn, an epidemiologist at Northwestern University in Chicago, Illinois, who co-authored two of the *JAMA* reports on the study. However, that wasn't known 16 years ago when the WHI was designed.

Not everyone is putting a brave face on the results though. Barbara Howard, an epidemiologist at the MedStar Research Institute in Hyattsville, Maryland, and lead investigator on another of the papers, says: "Now we know that for people this age, if you want to prevent colon cancer this isn't how to do it. Diet alone is not going to do it. There isn't one thing that you can or cannot eat that's suddenly going to protect you."

The results of the WHI are disappointing for another reason. Intervention studies may be the ideal option, but because of their cost and size only a handful have ever been attempted, and now some researchers worry that the WHI will make such studies even less appealing. "If that had been positive everybody would have said, 'Wow we need far more of these studies'," says Jebb. "In fact what it has done is make people nervous that they could invest tons of money and not get a statistically significant answer." Even so, the WHI has received funding to collect data for another five years, and other intervention studies are still going on.

In the absence of lots of intervention studies, what hope is there of ever getting definitive answers? If recent results are anything to go by, we can expect a lot more contradictory and confusing messages. Back in April a team led by Lee Hooper at the University of East Anglia in Norwich, UK, ▶

WHAT TO EAT

For the past 50 years the "food pyramid" has been the agreed basis of a healthy daily diet

SOURCE: USDA

Healthy and happy

What you eat affects more than just your physical health, says **Bijal Trivedi**

All kinds of foods, from Brussels sprouts to peanut butter and potatoes, have been touted as brain food. Sadly, these are little more than old wives' tales, but there is one well-known brain food that has solid evidence on its side: fish.

No nutrient has garnered as much supporting evidence for promoting mental health as long-chain omega-3 fatty acids, in particular eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are plentiful in oily fish such as tuna and salmon. And the potential benefits are huge: globally, more working days are lost to depression than any other illness. In the UK, 1 in 10 people are depressed at any given time, and for 1 in 20 it is a lifelong problem (*New Scientist*, 24 August 2002, p 34).

Back in 1998, Joseph Hibbeln, a psychiatrist and lipid biochemist at the National Institute on Alcohol Abuse and Alcoholism (NIAAA) in Bethesda, Maryland, noticed that depression was up to 60 times rarer in countries such as Taiwan and Japan, where people eat a lot of oily fish, compared with the US and Germany where they don't. In particular, he noticed that in countries that consume a lot of fish, rates of bipolar disorder, post-natal depression and seasonal affective disorder were lower.

In the intervening years Hibbeln and others have produced an impressive body of evidence that differences in intake of omega-3s are correlated with the prevalence of depressive disorders and that giving omega-3 supplements to depressed patients reduces their symptoms. "Each of these psychiatric disorders has been shown to be improved by omega-3 in double-blind placebo-controlled trials," says Hibbeln.

Your brain is what you eat

You don't have to be clinically depressed to benefit either. Healthy people with relatively low levels of omega-3 in their bloodstream are more likely to be mildly depressed, pessimistic and impulsive than those with high levels, according to research presented in March by Sarah Conklin of the University of Pittsburgh School of Medicine at the American Psychosomatic Society meeting in Denver, Colorado. "This is not magic," says Hibbeln, "just the psychiatric manifestations of omega-3 deficiencies in the brain."

Here's how it works. The brain is about 60 per cent fat, much of it making up the membranes that envelop nerve cells. The fats we eat influence their composition, and omega-3s are a particularly important membrane component: studies have shown that they make the membrane more fluid and flexible, rendering the cell more receptive to incoming signals. That's because when neurotransmitters dock with receptor proteins in the membranes, the receptors change shape, triggering a cascade of chemical reactions. The more fluid the membrane, the faster the signal propagates.

Historically the dietary ratio of omega-3s to another class of fatty acid, omega-6s, was about 1:1. In the past century, however, this ratio has shifted to more like 1:10 or 1:15 in western diets because of the introduction of seed oils such as soybean oil. Scientists believe that when the diet is low in omega-3s the brain compensates by substituting an omega-6, which alters the physical properties of membranes.

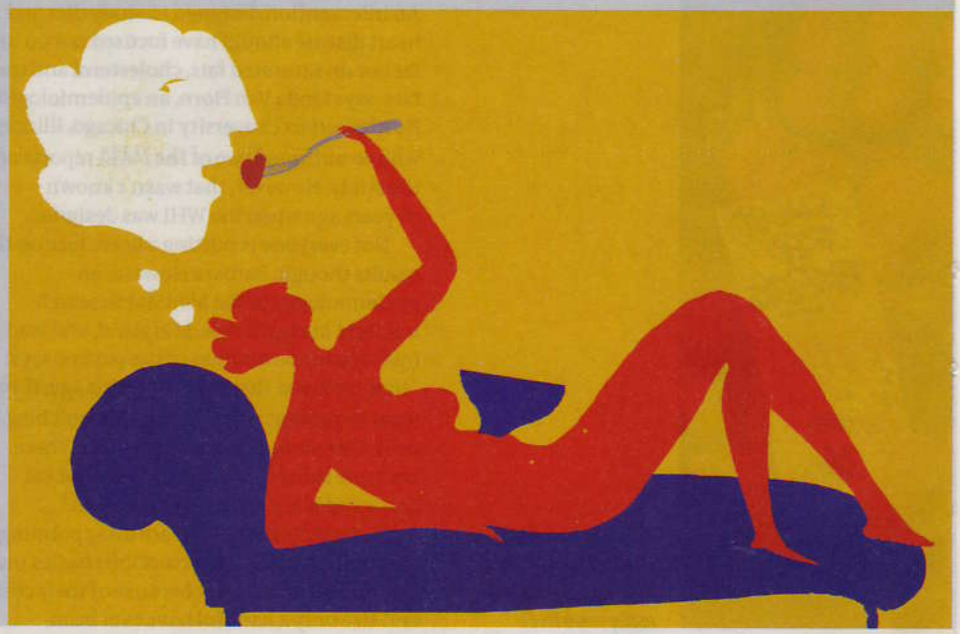
This omega-6 contains one fewer double bond in its carbon chain than omega-3s, making it more rigid. When the neuron's membrane contains too much omega-6 the receptors can't change their shape as easily, making them less responsive to signals. "It's like putting a dancer in a matrix of marshmallow fluff versus molasses and asking her to move," says Burton Litman, a membrane biophysicist at NIAAA.

In a recent experiment, Litman found that rats fed a diet deficient in omega-3s lost 80 per cent of the DHA in the membranes of their retinal cells, replaced with omega-6s. It also impaired their visual signalling (*The Journal of Biological Chemistry*, vol 279, p 31098). The retina's light-sensitive rhodopsin molecules, which generate the first signal in the visual cascade when light hits them, were unable to change shape as easily. With fewer rhodopsin molecules responding, the chemical pathway that produces the nerve impulse to the brain was less efficient and the final signal was weaker.

Hibbeln says that this probably happens in other parts of the central nervous system too. "I assume similar situations in other neuronal systems, [substituting other fats] slows down the system. You can't imagine that it is good," he says.

Omega-3s also seem to have another benefit, by promoting neuronal growth and so allowing the brain to repair damage. In a paper published in April, neuropsychiatrist Basant Puri at Imperial College London did "before and after" MRI scans on people

"This is not magic, just the effect of omega-3 on the brain"



LARA HARWOOD

with schizophrenia and Huntington's disease who were treated with EPA or a placebo (*International Review of Psychiatry*, vol 18, p 149). After six months those in the placebo group had clearly lost cerebral tissue, but in patients given the supplements, the amount of grey and white matter increased enormously. "This demonstrates that the brain uses these fatty acids amongst other things to sprout new dendrites and increase its mass," says Puri. These patients also experienced "amazing" improvements in cognition, he adds, with better short-term memory, arithmetic ability and concentration levels.

Encouraging results

Preliminary studies with omega-3 supplements have also shown encouraging results for schizophrenia, borderline personality disorder, dyslexia, autism, attention deficit hyperactivity disorder, obsessive compulsive disorder and dyspraxia, among others. However, cautions psychiatrist Bruce Cohen at Harvard Medical School, there are too few studies in most of these areas to be sure.

Omega-3s may also help the brain because they are anti-inflammatories, says Cohen. Both EPA and DHA are known to dampen inflammation in cardiovascular disease and may also suppress inflammatory processes in the brain, which are a hallmark of major psychotic disorders and dementias.

That too is the hypothesis for the brain-healing properties of brightly-coloured fruits and vegetables. Researchers speculate that this stems in turn from their antioxidant properties. Many mental illnesses are accompanied by oxidative stress to the brain caused by free radicals. This often leads to physical destruction of brain tissue, which is believed to trigger cognitive decline and low-level inflammation.

Preliminary research in rats suggest a diet high in antioxidants can slow down and to some degree reverse age-related behavioural, cognitive and motor decline. For example, a string of studies from Tufts University in the US show that spinach, blueberries and strawberries are particularly effective at slowing cognitive decline.

Evidence has also been building in favour of eating other foods rich in antioxidants, including ginger, green tea, coffee and turmeric.

However, rather than just one superfood emerging, researchers agree it is more likely that a constellation of different foods will be most effective at keeping the brain healthy – once again underscoring the value of a balanced diet.

MARTIN PARR/MAGNUM

If these are fried in trans fats then you should step away from the plate

published a review of almost 100 separate studies into omega-3 fatty acids, found in abundance in oily fish. It concluded – contrary to the WHO report – that they do not have a significant protective effect against cardiovascular disease.

"That was a very confusing analysis," says Jebb. "Their result caused a lot of surprise and consternation." The researchers' methodology has been criticised, but Jebb concedes "for the analysis they did and the way they defined their study, that was the answer: there wasn't a statistically significant benefit."

A similarly unexpected result was announced last year by the Pooling Project of Prospective Studies of Diet and Cancer, based at Harvard School of Public Health. They pooled the results of 13 different studies on dietary fibre involving 725,628 men and women and concluded that, contrary to earlier findings – including a similarly huge study published in 2003 (*The Lancet*, vol 361, p 1496) – high dietary fibre intake was not associated with a reduced risk of colorectal cancer (*The Journal of the American Medical Association*, vol 294, p 2904). "I'm not quite sure why we are seeing different results," says Stephanie Smith-Warner, a nutritional epidemiologist and the leader of the Pooling Project.

Yet despite all the bad news and unexpected reversals, scientists believe that progress is possible. Much depends on the development of new biochemical and genetic tools. For instance, biochemical tools could keep track of what research subjects actually eat. In observational studies, people tend to under report their calorie intake by about 25 per cent. Researchers rarely know what foods make up those unreported calories, and if you don't know what people are eating, you can't draw conclusions about their health. In interventions, meanwhile, people exaggerate their compliance. Both factors can drastically distort study results. Identifying suitable biomarkers would let researchers verify if a participant was indeed adhering to the intervention and reveal what other foods they might be eating.

Other researchers believe that nutritional studies could benefit from an infusion of genetics. One of these is David Mutch, a nutrigenomics specialist at the Pierre and Marie Curie University in Paris, France. He believes that because they use genetically diverse populations, large studies could be masking true links between diet and disease. "Genetics could be a valuable tool for revealing significant results for particular population subsets...and bring another level of comprehension to what's happening."

The organisers of the WHI share Mutch's belief. In hundreds of freezers in Rockville, Maryland, are tens of thousands of blood, urine and tissue samples from many of the study's participants, waiting to play a part. "As soon as we know more [about which genes are influenced by diet] we can refine our analyses," says Howard.

Until there is a more personalised approach to nutrition, sticking to that old staple, the food pyramid, is probably not a bad strategy. "My take on this is that the health effects are pretty clear but the detail is lacking," says Jebb. "Overall, based on the accumulation of information from different sources, the orthodoxies still hold. We have to believe that or we'd all just give up and do something else." ●

Bijal Trivedi is a writer based in Washington DC

www.newscientist.com/channel/health