

Essential fat facts

Fats are all around us

Fat: the gunk clogging up the world's arteries and sewers. We try to reduce our fat intake or burn it off by doing exercise. We wash it down the drain. We regard fat as bad, but it isn't always. Most of the time, actually, it's useful. We might think of fat as oil, grease or just waxy yellow stuff, but like proteins and carbohydrates it's made up of molecules that are nutrients and give structure to our cells.

Fats are lipids: molecules that dissolve in ethanol but not in water. As well as fats (made of fatty acids and glycerol), lipids include sterols like testosterone and cholesterol. Perhaps the most fundamental role of lipids is in compartmentalising life into cells – all living things from bacteria to humans use phospholipids to make up their cell membranes. Even viruses, which do not make their own lipids, use the fatty membranes of their host cells to multiply.

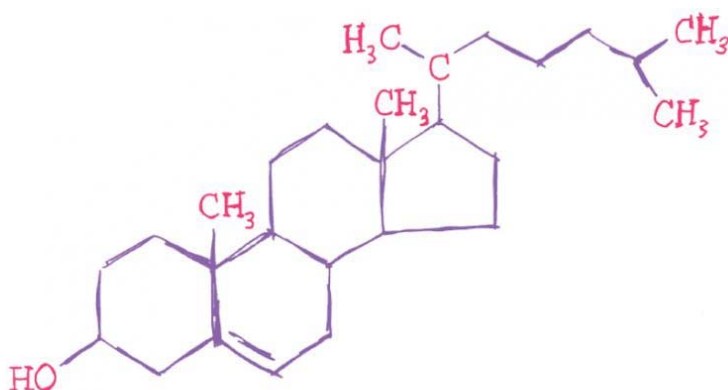
But lipids have far more wide-ranging functions. They are energy stores and thermal insulation for hibernating bears, fuel for marathon runners, and protective coatings that limit evaporation from plants. They are hormones, water repellents, and electrical insulation for nerve transmission. Lipids play such important roles that we and most other things in nature couldn't survive without them.

We use fat for a variety of activities

There are two main categories of fat in our bodies. The first is storage fat, which can be respired to release energy. The other is essential fat, which is found in our nerve cells, membranes and elsewhere, and is needed for the correct functioning of our bodies.

Men must maintain essential fat amounting to at least 3 per cent of their body mass and women around 12 per cent. It is thought that in women, this fat is important for fertility and childbearing.

Cholesterol



Cholesterol is a necessary part of all of us

Our notion of cholesterol as bad is overly simplistic. For example, it helps regulate the fluidity of cell membranes. And, in the context of health, often when we say 'cholesterol', we're actually referring to two cholesterol transporters found in the blood: high-density and low-density lipoprotein, otherwise known as HDL ('good') and LDL ('bad') cholesterol. (For more, see our animation film on cholesterol transport.)

While further subdivisions of LDL cholesterol do make the picture more complex, raised levels of LDL cholesterol are generally associated with an increased risk of heart disease.

According to most sources, it is not eating high-cholesterol foods, such as eggs, that drives up our blood cholesterol levels, but eating foods that are high in saturated fats. This is because our livers turn saturated fats like those in cakes and pastries into LDL cholesterol in the blood.

The past few years have seen continued questioning of dietary guidance on saturated fats and cholesterol. However, a 2015 study based on changing the diets of 195 people for 16 weeks showed that replacing saturated fats with unsaturated fats reduced LDL cholesterol levels.

Our cholesterol levels are not determined only by what we eat but also by the genes we inherit from our parents. About 1 in 500 people have an inherited condition called familial hypercholesterolaemia, which means they have high cholesterol from birth – whereas in 499 out of 500 people, cholesterol levels don't get higher until they get older.

The link between fats and vitamins

Fat-soluble vitamins like A, D and E are stored in the liver and adipose (fat) tissues, meaning the body can draw on supplies as and when it needs them. So we might get our vitamin E from plant oils, seeds or nuts, but we don't need to eat them every day to make sure we have enough.

Vitamin A is important for the development of a growing fetus, including the eyes, skin, bones and immune system. However, very high levels of vitamin A are thought to cause birth defects. Thus, although much of the evidence for these adverse effects comes from animal studies, pregnant women are advised not to eat liver or pâté, and not to take fish oil supplements, because they contain too much vitamin A.

Around 70 per cent of the body's vitamin A is stored in the form of retinyl ester molecules in large lipid droplets in the hepatic stellate cells of the liver. While adipose tissue contains less-concentrated stores, there is a lot of this tissue, so it may account for most of the remaining vitamin A.

In both liver and adipose tissue, specialised proteins called retinol-binding proteins help to put the vitamin into circulation so that it can be used elsewhere. Recent research, however, suggests that levels of retinolbinding proteins are raised in obese mice and humans, and that they may take part in signalling pathways contributing to type 2 diabetes.

Death in small doses: exploring the dangers of bioaccumulation

The consequence of a bad dinner choice

Pulling off a successful Arctic expedition is difficult. In the 1590s, it was even harder – and one notorious mission to Novaya Zemlya, an archipelago to the north of Russia, wasn't helped by an unusual malady. It affected three men particularly gorily: they were “exceeding sicke”, wrote Dutch officer Gerrit de Veer, “and we verily thought that we should have lost them, for all their skins came of [sic] from the foote to the head”.

The cause of the crew's skin loss (or 'desquamation') was their dinner. Owing to a shortage of supplies – and their inability to catch one of the seals near the camp – the men had killed a polar bear and unsuspectingly cooked and eaten its toxic liver. It's long been known that polar bear livers aren't safe to eat, but it wasn't until 1943 that the researchers Rodahl and Moore identified the problem as the livers' exceptionally high vitamin A content.

Vitamin A is fat-soluble and is chiefly stored in the liver. Too little of it in our diets can cause serious eye problems, including blindness, and an impaired immune system. Too much, and we're at risk of a long list of symptoms that includes desquamation, bone pain and an increased sensitivity to sunlight.

Most serious clinical cases of vitamin A overdose involve consuming a large amount in a short time. The effects of less drastic but long-term over-consumption are harder to judge, but a 2012 review of the evidence noted that vitamin A supplements in Western diets were "significantly associated with increased mortality".

Heavy metal

"Most of us should have more fish in our diet," says the NHS Choices website. However, it adds, "there are maximum recommended amounts for oily fish, crab and some types of white fish", particularly for pregnant or breastfeeding women. Why? Because of mercury.

Mercury is one of several toxic heavy metals that can accumulate in human soft tissues such as fat. Mercury poisoning primarily affects the central nervous system. It kills neurons and glial cells, causing problems with sight, speech, hearing and coordination. At worst, it can end in coma or death.

Fish consumption guidelines specifically address pregnant or breastfeeding women – or, in some cases, all women who might want children one day – because mercury especially affects developing fetuses and infants. A small child's body is less able than an adult's to handle the mercury in a serving of fish, and mercury can cross the placenta and affect fetuses in the womb.

How does mercury get into fish? Initially, mercury (or, more accurately, the form of mercury known as 'methylmercury') is present in the water. It's absorbed by algae, which is eaten by small fish; the small fish are eaten by larger fish higher up the food chain. Because of so-called biomagnification, larger fish are likely to contain a higher concentration of mercury in their bodies.

Methylmercury has a half-life of about 70 days and the fish don't excrete it, so it accumulates in the predator species. Modern shrimp, for example, contain an average of 0.1 parts per million (ppm) methylmercury, mackerel about 0.3 ppm and sharks more than 1.0 ppm.

Evidence for the harmful effects of mercury on people comes from disasters like the Japanese Minamata Bay poisoning of the 1950s, which began when the Chisso chemical plant dumped wastewater contaminated with mercury into the bay. This mercury entered the food chain and accumulated in higher predators.

The larger fish were then eaten by people. Many women in the region developed symptoms of mercury poisoning, although these were mostly minimal. But their children had serious neurological problems and were diagnosed with so-called 'Minamata disease' – essentially severe heavy metal poisoning.

QUESTIONS FOR DISCUSSION

- Animals with high levels of vitamin A in their livers include polar bears, arctic foxes, bearded seals and glaucous gulls. What else do these animals have in common?
- DDT (dichlorodiphenyltrichloroethane), like mercury, is a fat-soluble substance that biomagnifies. Look up DDT on the internet and compare the two: how else are they similar, and how are they different? Which do you think is more dangerous for humans and why?