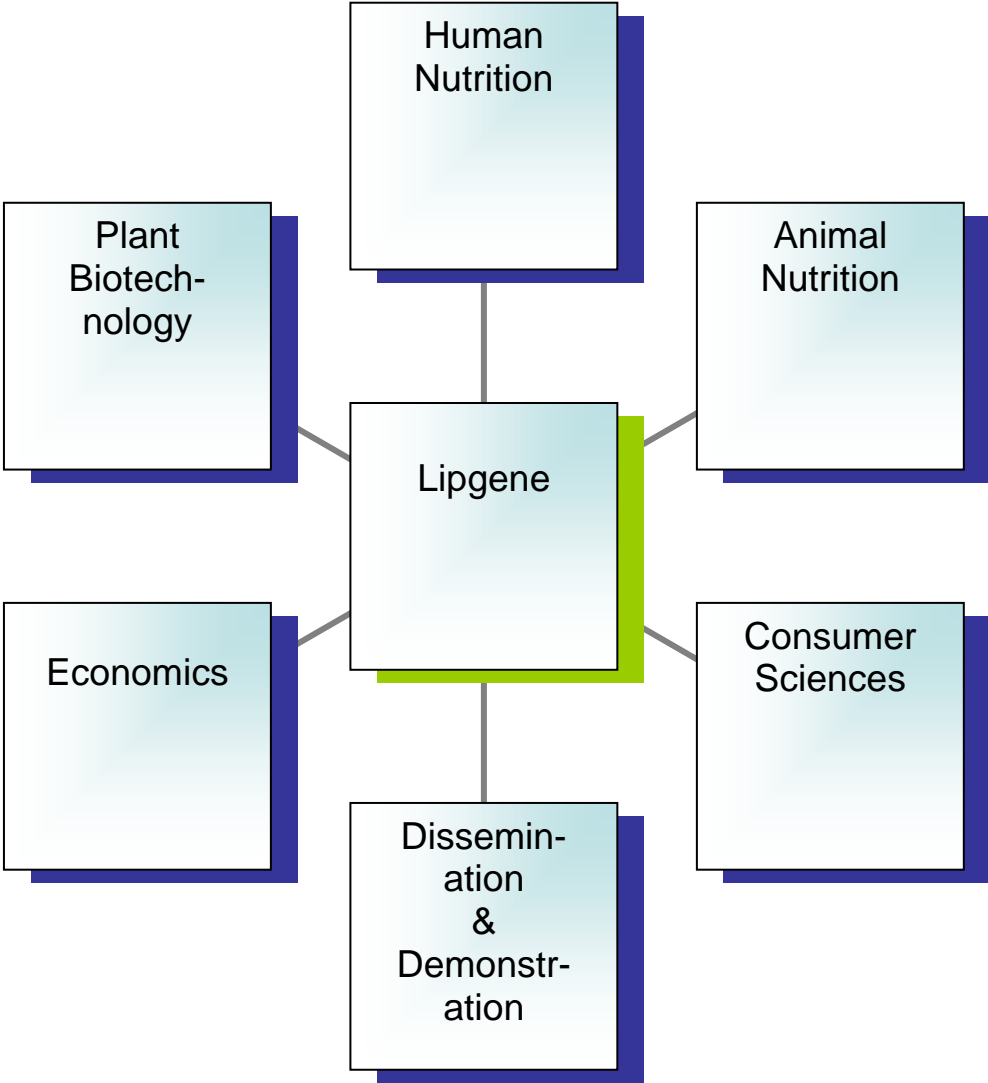


Lipgene: Some Questions & Answers:



Section 1: The *Lipgene* project

Q. *What is the main aim of Lipgene?*

A. The main aim of Lipgene is to investigate the interaction between dietary fat composition and genotype¹ in the development of the metabolic syndrome. It will draw upon knowledge gained from research in the areas of human nutrition, plant biotechnology, animal nutrition, economics and consumer science.

Q. *Which countries are involved in Lipgene?*

A. 10 European countries are involved in the *Lipgene* project. These are: Ireland, United Kingdom, Norway, Spain, France, Poland, The Netherlands, Finland, Portugal and Germany. The *Lipgene* consortium comprises of 22 organisations:

Human Nutrition

- Trinity College Dublin, Ireland*
- University of Reading, United Kingdom
- University of Oslo, Norway
- University of Bergen, Norway
- INSERM, France
- University of Cordoba, Spain
- NUTRIM, Maastricht, The Netherlands
- University of Upsalla, Sweden
- University of Krakow, Poland
- Unilever Best Foods,
- Hitachi, Europe Limited

Dissemination

- British Nutrition Foundation

Plant Biotechnology

- BASF Plant Science GmbH, Germany
- University of York, UK
- Rothamstead Research, UK

Animal Nutrition

- University of Reading, UK
- Rowett Research Institute, UK
- MTT Agrifoods Research, Finland
- INRA, France

Economic Science

- LMC International

Consumer Science

- University of Porto, Portugal
- University of Ulster at Coleraine, Northern Ireland.
- Trinity College, Dublin*

*partner is involved in more than one workpackage

¹Glossary terms are underlined throughout the text

Q. How many people are participating in the research?

A. Currently, there are at least >184 scientists and staff working on the project.

A large number of people will also take part as volunteers in *Lipgene*. The human nutrition workpackages will include a prospective nested case-control genetic study (involving 13,000 men and women; [SUVIMAX](#)) and a human dietary intervention study (involving 480 volunteers with the metabolic syndrome from eight cities across Europe).

Q. How long will the project last?

A. *Lipgene* is a 5-year project which started in February 2004. It is one of the first of the European Commission's 6th Framework Programme integrated projects, which are a new feature of Framework Programme Six. If you would like to know more information about Framework Programme Six, log onto <http://fp6.cordis.lu/fp6/home.cfm>.

Q. Where will the results be published?

A. Results from the *Lipgene* project will be published in appropriate peer-reviewed scientific journals. The *Lipgene* website will also publish updates as results become available (www.lipgene.tcd.ie).

Lipgene also includes an integrated dissemination workpackage, run by the British Nutrition Foundation, the aim of which is to ensure that the results and outcomes of *Lipgene* are distributed to a wide network of people and organisations. A feature of this workpackage is a series of *ad hoc* e-mail alerts, which will inform network members about project news and events. Anyone can join this network by clicking on the link on the *Lipgene* websites and submitting their contact details (www.lipgene.tcd.ie or www.nutrition.org.uk/lipgene). Other components of the dissemination workpackage will be an annual conference or workshop series, regular update articles in *Nutrition Bulletin* and periodic project reports and summaries at www.nutrition.org.uk/lipgene.

Section 2: Obesity, metabolic syndrome and *Lipgene*

Q. What is obesity?

A. Put simply, obesity is the presence of an excess amount of total body fat.

Obesity can also be defined as a [body mass index](#) (BMI) of 30 or over. Although there is a positive correlation between BMI and percentage of body fat, BMI is not a perfect indicator of obesity as it does not distinguish between fat and fat-free mass: e.g. muscular individuals may have a high BMI without necessarily having excess body fat. BMI is an inappropriate assessment tool for some athletes and is also not suitable for pregnant women, for some ethnic groups, or for use in some medical conditions or in children.

Obesity has also been defined as a body fat content of over 25% for men and over 33% for women; however, measurement of body fat requires specialised methodology.

Obesity is a well-recognised hazard to health, and obese people are at increased risk of a range of diseases and early death; it has been estimated that being obese can reduce life expectancy by 9 years. More information about obesity is available on the BNF website.

Q. How prevalent is obesity in Europe?

A. Obesity is very prevalent. It is a major public health problem throughout Europe, especially among women in southern and eastern European countries; rates of obesity in the Baltic Republics are among the highest in the world.

National surveys in European countries indicate that between 10 and 20% of men and 10 to 25% of women are obese. Rates of obesity differ between countries but, in the majority of European countries, the prevalence of obesity has increased by between 10 and 50% in the last 10 years. The most dramatic increase has been in the UK, where prevalence has increased threefold in 20 years; over 20% of adults in the UK are now obese.

Obesity is now more common in children too. For example in England in 2002, 5.5% of boys and 7.2% of girls aged 2-15 years were obese. In total, 1 in 5 boys and 1 in 4 girls aged 2-15 years were classified as either overweight or obese using recent international classifications.

As the prevalence of obesity rises, and in an ageing European population, it is expected that the prevalence of the metabolic syndrome will also increase significantly.

Q. What is the Metabolic Syndrome?

A. An excess of body fat, especially [abdominal obesity](#), leads to impaired glucose and lipid metabolism, which leads to hyperinsulinaemia (a high blood insulin level, also known as insulin resistance). At its most severe this leads to diabetes; less severe degrees of insulin resistance lead to a multi-component disease known as the metabolic syndrome.

The metabolic syndrome describes a cluster of risk factors for heart disease and stroke, namely abdominal obesity, abnormal blood lipids ([dyslipidaemia](#)), insulin resistance and high blood pressure. The risk of developing metabolic syndrome increases with age. The metabolic syndrome is associated with an increased risk of cardiovascular disease (heart disease and stroke).

Q. How prevalent is the metabolic syndrome?

A. At the moment, the true prevalence of the disease is unknown. In the UK, it has been suggested that as many as 25% of the adult population show clear signs of the metabolic syndrome. In the US, it is estimated that 44% of the population over 50 years of age meet the criteria for the metabolic syndrome. These figures are expected to increase in parallel with the rising epidemic of obesity. Incidence is higher in certain ethnic subgroups (e.g. Asian and African-Caribbean groups), in

women with polycystic ovary disease, and in patients with schizophrenia and those with non-alcoholic fatty liver disease. The uncertainty over the precise prevalence is partly because of the lack of an accepted definition for the metabolic syndrome – a number of different definitions exist. Nevertheless, it is accepted that globally, the incidence of the metabolic syndrome is rising at an alarming rate.

Q. What is insulin?

A. Insulin is a hormone produced by the pancreas in response to food intake. Insulin circulates in the blood and assists in the movement of glucose into cells where it is used as a source of energy or stored for future use as glycogen.

Q. What is insulin resistance?

A. Insulin resistance is a condition in which the body's cells are less responsive (or less sensitive) to the action of insulin. Insulin resistance occurs when the normal amount of insulin is secreted by the pancreas, but it is not accepted and used properly by the body's cells, and as a result the amount of glucose in the blood becomes too high (hyperglycaemia). To maintain a normal glucose, the pancreas secretes additional insulin but, for some people, the body's cells still do not respond normally, even with the extra insulin. This situation can lead to profound insulin resistance and type 2 diabetes, in which blood glucose levels remain high. Insulin resistance is more common in people who have central or [abdominal obesity](#), and is a key characteristic of the metabolic syndrome.

The composition of dietary fat is known to have an influence on insulin resistance and scientists are in the early stages of discovering how genetic variation interacts with this insulin resistance.

Q. What factors are involved in the development of the metabolic syndrome?

A. The underlying cause of the metabolic syndrome is unknown, but insulin resistance and obesity are thought to be key. The most frequent combination of symptoms of the metabolic syndrome is obesity (or abdominal obesity) with [hypertension](#) or [dyslipidaemia](#), which is observed in 50% of patients with type 2 diabetes and in 10-20% of subjects with normal [glucose tolerance](#). It should also be noted that features of the metabolic syndrome may also be present in individuals who are normoglycaemic (have a normal blood glucose level) and who may never develop type 2 diabetes.

Q. How is the metabolic syndrome diagnosed?

A. There is no agreed method to diagnose the metabolic syndrome; at least three different definitions exist to describe the metabolic syndrome: most focus on obesity and insulin resistance. (More information about these definitions is available on the BNF website). Some of the **clinical features** of the metabolic syndrome are listed below:

- Obesity /central (abdominal) obesity
- Impaired glucose tolerance

- Raised blood pressure / hypertension
- Dyslipidaemia
 - [Hypertriglyceridaemia](#)
 - Elevated [apolipoprotein B](#)
 - [Small dense LDL-cholesterol](#) levels
 - Reduced [HDL-cholesterol](#)
- [Microalbuminaemia](#)
- [Hyperuricaemia](#) and gout
- Markers of chronic inflammation
 - Raised [C-reactive protein](#) (CRP) levels
 - Pro-inflammatory [cytokines](#)
- Increased [sympathetic nervous system](#) activity and low heart rate variability
- Abnormalities in blood clotting
- Low cardio-respiratory fitness
- Presence of fatty liver disease or polycystic ovary syndrome.

Q. What are the possible implications of having the metabolic syndrome?

A. Having the clinical features of the metabolic syndrome puts an individual at greater risk of heart disease, stroke and type 2 diabetes, all of which can lead to severe disability (such as kidney and eye disease) and even premature death. It is estimated that individuals with the metabolic syndrome are approximately 2-4 times as likely to suffer from heart disease and stroke compared with normal healthy people.

An increasing prevalence of the metabolic syndrome (and its associated morbidities) has implications both for employers (due to an increased number of sick days) and for social welfare and healthcare costs. In Europe, the treatment of obesity related diseases is now a major contributor to the cost of health care, accounting for approx. 8% of all medical costs and this figure is likely to increase.

Q. What are healthy / unhealthy fats?

A. The building blocks of fats are known as fatty acids. Foods usually contain a combination of different types of fatty acids, the properties of which depend on their chemical structure and the number of molecules present. Three major types of fatty acids exist: saturates, monounsaturates and polyunsaturates and the balance of these within a food is important.

As a rough guide, saturates are solid at room temperature and tend to be derived from animal sources. Most unsaturates (monounsaturates and polyunsaturates) are liquid at room temperature and are usually vegetable fats. There are, however, exceptions: palm oil is a vegetable oil which contains a high percentage of saturated fatty acids. Vegetable and fish oils can also be hardened by a process which adds hydrogen atoms to some of the double bonds in the unsaturated fatty acids. This is known as hydrogenation. For more information, log onto www.nutrition.org.uk/saturates.

Saturates are present in large amounts in:

- butter and some other fat spreads e.g. hard margarines

- foods fried or made with these fats, such as biscuits, pastries, pies and cakes
- fatty cuts of meat and meat products e.g. salami.

Saturates are thought to be associated with increased levels of harmful **LDL-cholesterol** in the blood, which in turn increase the risk of developing cardiovascular disease.

Monounsaturates and polyunsaturates are thought to be healthier than saturates. Some rich sources of monounsaturates are olive oil and rapeseed oil. Rich sources of **n-6 polyunsaturates** include vegetable oils such as sunflower seed oil and soyabean oil. Another type of fat is **n-3 long chain polyunsaturated fatty acids**. n-3 polyunsaturates are found mainly in oily fish such as salmon, fresh tuna and sardines, and also in fish oil supplements. They are thought to confer considerable benefits to heart health and to immune function. For more information about dietary fat see www.nutrition.org.uk.

Lipgene will carry out investigations into the use of modern technology to modify the fat composition of a range of foods so that they contain less of the saturated fatty acids and more of the long chain polyunsaturated fatty acids found in fish oil. The foods to be used in these 'demonstration projects' include cheese, milk, poultry meat and margarine.

Q. Can risks associated with the metabolic syndrome be reduced by diet?

A. Several studies have shown that diet (and exercise) interventions can slow the progression of the metabolic syndrome. In general, the dietary advice given in these studies reflected general population dietary advice for the consumption of total energy (calories), protein, fat and carbohydrate, while encouraging participants to eat more fruit and vegetables, reduce sugar intake and control alcohol consumption. Rather than focus on total fat consumption, *Lipgene* will carry out a large study to look at what happens to people who are at risk of the metabolic syndrome if they change the types of fat (and the balance of fatty acids) in their diet. The aim of the study is to answer questions such as:

'How much of an improvement is possible using diet alone?'

and

'Are some people more sensitive to certain types of fat?'

Q. What is a polymorphism?

A. Put simply, a polymorphism is a common genetic variation, or a change in the genetic sequence (code), that may predispose an individual to developing a particular condition. For example, we know that there are a number of variations found in the gene that codes for the enzyme methylenetetrahydrofolate reductase (**MTHFR**). A strong link exists between folic acid, MTHFR and heart disease. A polymorphism on the MTHFR gene (677-T) results in an enzyme activity of approximately 50% of its normal value, and this leads to elevated homocysteine levels and an increased risk of cardiovascular disease. A polymorphism (also called

a single nucleotide polymorphism or SNP) must have a frequency of at least 1% in the population.

Q. How is genetic variation associated with the metabolic syndrome?

A. Several genetic variations associated with the metabolic syndrome have so far been identified. These include genes associated directly with fat stores and lipid (fat) metabolism, genes associated with inflammation, and genes associated with insulin resistance. A primary focus of *Lipgene* will be to identify interactions between dietary lipids and [genotypes](#) involved in the development of the metabolic syndrome.

Q. What is genotyping?

A. Genotyping is the procedure used to identify the specific sequence of [genes](#) in a sample of DNA. The procedure can be used to identify similarities or differences in the sequence of genes and is useful in establishing whether an individual may be genetically predisposed to a disease or condition.

Q. What is nutrigenomics?

A. Nutrigenomics (nutritional genomics) refers to the interaction between dietary constituents and the [human genome](#). It explores the way in which nutrients impact on the production and action of specific gene products and how these, in turn, affect the response to nutrients. Individual [genetic variation](#) may exacerbate (make more prominent) the role of diet as a risk factor for disease. Dietary interventions (or 'tailored' diets), based on knowledge of nutritional status, nutritional requirement and genotype (identified gene sequence) have been suggested as a means of remedying or improving disease symptoms.

Section 3: Biotechnology

Q. What is selective breeding?

A. Selective breeding occurs when animals and plants with the most desirable characteristics for use as food and feed are chosen for breeding the next generation. Man has been practising selective breeding for centuries and it has resulted in the creation of strains of wheat with twice the yield, strains of corn with resistance to fungus, and even giant pumpkins. In short, it involves choosing animals and plants which have a desirable genetic code.

Q. What are genetically modified foods?

A. Genetically modified (GM) foods are a modern-day follow-up to selective breeding. Using modern genetic techniques, scientists are able to insert specific 'desirable' genes into plants or animals, without the 'trial and error' approach of selective breeding. GM is therefore much quicker than selective breeding. Plants and animals whose genetic material has been altered in such a way are called genetically modified organisms (GMO). GM foods may contain genetic information that was

altered by deletion or addition of information from the same or a different organism, and the genetic alteration can give a food or animal feed specifically desired properties. This has been used to mankind's advantage in certain circumstances. For example, GM has been used to minimise crop losses, by making them resistant to insects and diseases and by reducing the amount of crop spray needed to keep plants healthy.

Other uses of GM are in food technology and in healthcare. To replace the use of animal-derived rennet in cheese making, GM technology has been used to derive an effective enzyme from microbiological sources. GM has also brought some changes in healthcare, e.g. it is used in the production of recombinant insulin which is needed in the treatment of diabetes.

Q. How will Lipgene use GM technology?

A. One of the workpackages in *Lipgene* focuses on [plant biotechnology](#) with the aim of increasing and optimising the quality of *n*-3 polyunsaturated fatty acids (PUFA) in vegetable (linseed) oil for human health. Using genetic engineering technology, the genes involved in the synthesis of *n*-3 polyunsaturates in marine algae will be used to develop a linseed oil with *n*-3 polyunsaturates that occur only in marine foods i.e. [eicosapentaenoic acid \(EPA\)](#) and [docosahexaenoic acid \(DHA\)](#). Following a full characterisation of the biochemical (enzyme) pathways involved in the synthesis of EPA and DHA, it is hoped to be able to functionally express the required enzymes in linseed and then to produce large amounts of seed material. Then, as part of the animal nutrition workpackage, pigs and poultry will be supplemented with animal feed enriched with this *n*-3 rich linseed oil. It is hoped to produce *n*-3 enriched poultry meat and pork that is acceptable to consumers and does not have a compromised taste, shelf life or oxidative stability.

Q. Why is Lipgene using GM technology?

A. *n*-3 polyunsaturates can confer considerable benefits to heart health and insulin sensitivity and it is recommended that we eat more of the *n*-3 polyunsaturates found in oily fish (e.g. salmon, herring, and mackerel) as part of our diets. In the UK, it is recommended that girls, pregnant women and women of child bearing age eat up to two portions of oily fish each week, and that men, boys and women past child bearing age eat up to four portions a week. However fish stocks are limited and not everyone eats fish. For example, in the UK, 70% of people typically do not eat it and average weekly intakes are approximately one third of a serving per person. Therefore an alternative sustainable source of long chain *n*-3 polyunsaturates is needed to ensure optimal levels are achieved in the diet. *Lipgene* will use GM technology to produce such alternative sources of *n*-3 polyunsaturates e.g. *n*-3 enriched milk, butter and meat.

Q. Will the use of another species genes in a food affect the properties of that food, e.g. taste.

A. Taste is a very important factor determining people's food choices. It is anticipated that taste will not be compromised when poultry meat is produced with a higher

content of *n*-3 polyunsaturates, using feed developed by genetic engineering technology. However, this will be examined using consumer taste panels.

Section 4: Animal Nutrition

Q. Can dairy cows be made to produce milk with less fat?

A. Yes. With some difficulty and by making fairly substantial changes to the cow's diet, in a manner that does not compromise the animal's health and ensures that all nutritional needs are met, a lower fat milk can be produced. However, one important factor is that, at present, farmers get paid for milk at a rate which is dependant on milk fat content. There would clearly need to be a financial incentive to produce milk of lower fat content.

Q. What is the contribution of meat and milk to dietary intake of fat and saturates in particular?

A. Across EU member states, dairy products and meat/meat products contribute 15-40% and 10-30% respectively of total fat consumed, depending on the country and the nature of the diet typically eaten. For saturates the respective figures are 30-60% and 15-30%. Although there is clearly quite a difference between countries, it is clear that together these foods make the biggest single contribution to saturates intake. More information about dietary intakes of total fat and saturates is available at www.nutrition.org.uk.

Q. Can the amount of saturated fatty acids in milk be reduced?

A. Yes. Most of the saturated fatty acids in milk are made up of medium chain length fatty acid produced in the cow's mammary gland. By adding longer chain fatty acids to the cow's diet, the production of saturates by the mammary gland is reduced. The mammary gland also has the ability to convert some saturated fatty acids into unsaturated ones. In *Lipgene*, it is planned to examine ways in which this process can be manipulated to produce a milk with a modified fatty acid profile.

Q. Will changing the fat composition of milk affect any other nutrients?

A. It depends. Reducing the amount of fat in milk will obviously be expected to reduce the amounts of [fat-soluble vitamins](#) that milk provides but on the other hand the amounts of protein and calcium are likely to be slightly greater. Changing the composition of the fat itself is unlikely to have any major impact on other nutrients.

Q. Can the fat content of meat be modified by changing animal diets?

A. The opportunity for this is limited. The fat content of meat is largely related to the breed of the animal and its age at slaughter. In general, late-maturing breeds produce leaner meat. Changes to the composition of the fat in the meat can however be made by changing the animal's diet.

Q. Why is Lipgene attempting to increase the n-3 fatty acid content of foods?

A. An increased intake of the very long chain n-3 fatty acids typical of those in fish (e.g. [EPA and DHA](#)) has been shown to reduce the risk of coronary heart disease, reduce blood pressure and give other benefits related to the metabolic syndrome. It is very difficult to enhance the concentrations of these very long chain fatty acids in milk but it is more feasible to do this in meat from pigs and poultry. *Lipgene* is concentrating on the enhancement of poultry and pig meat.

Section 5: Consumer Science

Q. How can people identify whether a food contains genetically modified ingredients?

A. By looking at the food label. In April 2004 new rules for GM labelling came into force within the EU. The presence in foods of genetically modified organisms (GMOs) or ingredients produced from GMOs must be indicated on the labels. Foods produced with GM technology (e.g. cheese produced with GM enzymes) and products such as meat, milk and eggs from animals fed on GM animal feed will not have to be labelled.

Q. How will Lipgene check whether the new technology is acceptable to consumers?

A. One of the workpackages in *Lipgene* will include an analysis of consumers' attitudes to the metabolic syndrome, the new agrofood technologies, and to the use of genomics in the provision of tailored nutrition advice. The workpackage will include a series of focus groups, which will be used to explore consumer awareness and information needs about the metabolic syndrome.

Section 6: Economics

Q. What is the estimated cost of obesity in Europe?

A. It is very high. In several countries, the cost of obesity is estimated to account for 5% of total public health expenditure. Most of this is attributable to the treatment of older people suffering from obesity-related conditions associated with the metabolic syndrome, including high blood pressure ([hypertension](#)), type 2 diabetes, and high levels of some fats in the blood ([dyslipidaemia](#)).

One of the aims of *Lipgene* is to assess the true cost of obesity-related health problems. A detailed economic analysis of the current and predicted future healthcare costs associated with the metabolic syndrome across the EU will be performed.

Q. Why are people concerned about the burden of obesity?

A. Concern exists mainly because of the massive impact obesity could have on quality of life and on available health service resources. Obesity-related disease is expensive to treat or control, and is also resource intensive. As the population of Europe is getting older (it is projected that by 2030 nearly one third of Europeans will

be over 60 years of age), and fatter, the cost of obesity-related disease treatment is set to rise.

Q. Is drug (pharmaceutical) treatment of obesity-related disease, including the metabolic syndrome, more economical than diet and exercise modification?

A. Maybe not. It has been suggested that diet and exercise are better than drug treatment for obesity-related diabetes. However, drug therapies are currently used in the control of various components of the metabolic syndrome; [statins](#), for example, are used to improve blood lipid profile. A number of drugs for controlling blood pressure, obesity and blood sugars are also used.

One of the *Lipgene* workpackages will specifically compare the implications of pharmacological (drug) therapies with population-based nutrition intervention strategies (as used in the human nutrition workpackages) as a means of tackling the metabolic syndrome. This workpackage will specifically analyse the economic implications of altering the composition of dietary fat, as a means to reduce the economic burden associated with the metabolic syndrome. Finally it will assess the costs/benefits to healthcare of introducing a fatty acid modified food, and to the food industry of implementing the new agro-food technologies.

Section 6: Dissemination and Demonstration

A. Will people accept and eat the new foods?

A. Towards the end of the project, a range of food prototypes with an optimised fatty-acid content will be produced. Food types will include cheese, milk, poultry meat and margarine (see section 2). Their production will take advantage of innovations in the area of food processing, animal feeding and plant biotechnology industries and will be based on the research findings from *Lipgene*. These food prototypes will be evaluated by consumers for their acceptability as foods, taking account of stability, and sensory and functional performance attributes e.g. taste, mouthfeel, texture, smell and shelf-life.

A. How will people know about these new foods and about *Lipgene*?

A. In addition to the dissemination workpackage outlined in Section 1, it is anticipated that the project results and the activities incorporated in the dissemination workpackage will generate media interest and publicity, which will in turn help people to find out more about *Lipgene* and any new food prototypes. If you would like to keep up to date with the project's progress, register at www.nutrition.org.uk/lipgene.

Glossary

Abdominal obesity: the accumulation of body fat around the central part of the body (stomach region).

Apolipoprotein B (apoB): One of the proteins of the low-density lipoprotein which transports lipid and cholesterol to the tissues. Also present in very-low-density lipoprotein.

Atherosclerosis: The process in which fatty and fibrous deposits cause thickening and hardening of the arterial walls.

Body mass index (BMI): An index of obesity calculated as weight in kilogrammes divided by the square of height in metres ($w \div h^2$).

C-reactive protein (CRP) A plasma protein that rises in the blood with inflammation.

Docosahexaenoic acid (DHA): A long chain *n*-3 (omega-3) fatty acid that is abundant in oil-rich fish (see also *eicosapentaenoic acid*). Epidemiologic and clinical trial data suggest that these *n*-3 fatty acids may reduce the risk of cardiovascular disease. Possible mechanisms include anti-arrhythmic properties with regard to heart beat, improved endothelial function in blood vessels, anti-inflammatory action and reductions in blood triglyceride concentrations

Dyslipidaemia: An abnormal concentration in the blood of one or more lipids, such as an elevated low-density lipoprotein (LDL) cholesterol level or a raised triglyceride level or a depressed high-density lipoprotein (HDL) cholesterol level.

Eicosapentaenoic acid (EPA): A long chain *n*-3 (omega-3) fatty acid that is abundant in oil-rich fish, e.g. salmon, herring, mackerel (see also *docosahexaenoic acid*).

Fat-soluble vitamins: The vitamins A, D, E and K.

Folate/folic acid: Folate is a B vitamin found in green leafy vegetables (especially sprouts, spinach, green beans, peas), potatoes, fruit (especially oranges), milk and dairy products. A synthetic form (folic acid) is also found in some fortified foods (e.g. breakfast cereals, bread, yeast extract) and in vitamin supplements. Folate/Folic acid is necessary for the formation of healthy blood cells and reduces the risk of neural tube defects developing during pregnancy.

Gene: Unit of heredity in a chromosome controlling a particular inherited characteristic of an individual.

Genetic variation: variation in the genetic sequence (code)

Genetic: Inherited; a genetic disease is one that is inherited via a faulty gene.

Genotype: The genetic constitution (the genome) of a cell, an individual or an organism. The genotype is distinct from its expressed features, or phenotype (see. phenotype). Environmental factors (such as smoking, alcohol and diet) can influence genotype, and individual genetic variation may exacerbate the impact of these environmental factors as risk factors for disease.

Glucose tolerance: The body's ability to metabolise carbohydrate and efficiently use and store glucose. A glucose tolerance test is usually used to assist in the diagnosis of diabetes.

High-density lipoprotein (HDL)-cholesterol: Circulating lipid particles defined by size, density and apolipoprotein content. HDL particles transport cholesterol from cells to the liver, where they are degraded or repackaged. HDLs are responsible for removing excess cholesterol from the blood, preventing a build-up of cholesterol on the artery walls. This is why HDL-cholesterol is referred to as 'good' cholesterol. High levels of HDL-cholesterol are associated with low risk of coronary heart disease (CHD).

Homocysteine: A sulphur containing amino acid derived from the metabolic conversion of methionine (an essential amino acid). The conversion is dependent on vitamins (folate, B₁₂, and B₆) as cofactors or cosubstrates. Excess homocysteine in the blood may irritate blood vessels leading to damage to, and thickening of the vessel wall ([atherosclerosis](#)) blockages.

Human genome: the entire human genetic sequence (approx. 30, 000 genes).

Hyperglycaemia: A greater than normal concentration of glucose in the blood, most frequently associated with diabetes mellitus.

Hypertension: Elevated blood pressure (usually defined as a blood pressure of 140/90 mmHg or above).

Hypertriglyceridaemia: Concentrations of triglycerides in the blood higher than normal (or reference) values.

Hyperuricaemia: excess uric acid in the blood which can lead to the development of gout.

Low-density lipoprotein (LDL)-cholesterol: LDL particles deliver cholesterol to tissues where it is needed for membrane structure or to manufacture steroid hormones and bile acids. Too much LDL-cholesterol in the blood leads to a build-up of cholesterol (referred to as plaques) in the artery walls. These build-ups can eventually lead to ischaemia and thrombosis, by impeding adequate perfusion of the tissues with blood carrying oxygen. If this blockage is in the blood vessels feeding the muscle of the heart, this may result in a heart attack. This is why LDL-cholesterol is referred to as 'bad' cholesterol. A high-fat diet can result in raised LDL-cholesterol levels in the blood.

Methyl-tetrahydrofolate reductase (MTHFR): An enzyme that is required to convert homocysteine to methionine. Impaired activity of this enzyme results in increased blood levels of homocysteine.

Microalbuminuria: Excretion of small amounts of the protein albumin, found on urine tests.

Monounsaturates (monounsaturated fatty acids): Fatty acids containing one double bond in their carbon chain skeleton.

***n*-3 (or omega-3) polyunsaturates:** Fatty acids with more than one double bond and with their first double bond at the third carbon atom from the methyl end (-CH₃) of the molecule. These include alpha linolenic acid (C18:3) (sources of which include rapeseed, walnut, soya & blended vegetable oils), eicosapentaenoic acid (C20:5) and docosahexaenoic acid (C22:6) (the main sources of which are oil-rich fish) (see also **eicosapentaenoic acid** and **docosapentaenoic acid**).

***n*-6 (or omega-6) polyunsaturates:** Fatty acids with more than one double bond and their first double bond at the sixth carbon atom from the methyl end (-CH₃) of the molecule. These are the typical fatty acids of vegetable oils (e.g. sunflower, corn and soyabean) and spreads made from these.

Phenotype: The physical characteristics of an individual that result from the combination of genetic and environmental factors. By contrast, the genotype is merely the genetic constitution (genome) of an individual (see genotype).

Plant biotechnology: A field of biotechnology, which involves the introduction of foreign genes into plants, resulting in crop improvement and the production of novel products in plants. Usually economically important plant species are chosen. There are two main study areas within plant biotechnology: tissue culture and plant genetic engineering.

Polymorphism: The existence of variation of a genetic characteristic in a population that is too common to be due merely to new mutation. A polymorphism must have a frequency of at least 1% in the population.

Cytokines: Small, hormone-like proteins released by leukocytes, endothelial cells, and other cells to promote an inflammatory immune response to an injury.

Small, dense low-density lipoprotein (LDL) cholesterol: LDL particles vary with respect to their size, density, composition and physio-chemical properties. An increased proportion of small, dense LDL is associated with increased cardiovascular risk. This has been attributed to several factors, including greater susceptibility to oxidative modification and efficient infiltration into the arterial vessel wall.

Statins: A group of drugs that reduce the concentration of low-density lipoprotein (LDL) cholesterol in the blood.

SUVIMAX: The Supplementation en Vitamines et Minéraux Antioxydants (SUVIMAX) study is a prospective population-based cohort study involving 13 000 men and women (ages 45-60 years and 35-60 years respectively) who were studied over 7 years in France. Data were collected during this study on biochemical, clinical and genetic characteristics, and dietary intakes of these subjects.

Sympathetic nervous system: Part of the nervous system that prepares the body for activity by raising blood pressure and speeding up the heart rate.

Very-low-density lipoprotein (VLDL): A class of lipoproteins that transports triglycerides from the liver to the adipose and muscle tissues. They are produced mainly in the liver and primarily contain triglycerides in their lipid cores.