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Pills just for you

Your genetic makeup determines how you respond to medication, so has the time come to tailor treatments to suit the individual?

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Genetically personalised medicines may reduce the estimated £446 million a year which goes towards treating patients with adverse reactions to common drugs. Photograph: Piko Bsip/Science photo library

Personalised medicine is nothing new; it's your doctor knowing you, your values, family and life circumstances, and tailoring treatment by trial and error. However, the completion of the Human Genome Project in 2003 led to a flood of predictions that there would be a revolution in the field. Our ability to pinpoint individual risks to disease and to make specific drugs to treat them would be revolutionised, it was claimed.

Francis Collins, then director of the National Human Genome Research Institute, predicted that diseases with genetically identifiable contributions – diabetes, heart disease, high blood pressure, schizophrenia, multiple sclerosis – would be part of a group undergoing a "proliferation of discoveries ... and we're going to see the consequences of that in the next three to five years".

These projections have proved premature says Dr Philippa Brice, head of knowledge at the Foundation for Genomics and Population Health, "even though we had it on very good authority that within 10 years of the human genome being mapped we'd have perfectly tailored prevention". So exactly where is personalised medicine today?

At any given time, nearly 1,000 NHS hospital beds and an estimated £466m per year go towards treating people for bad reactions to common drugs. We now know our genetic profile accounts for much of our response to drugs, and widespread genetically

personalised treatment is still in its early stages, used sparingly in a number of doctor-delivered genetic tests aimed at preventing bad drug reactions. Codeine, one of the major pain relief medications used by UK patients, relies upon the production of enzyme CYP2D6. Nearly 10% of Caucasians have a mutation on the gene that codes for enzyme CYP2D6, making them immune to codeine, no matter how high the dose. There are a number of things that can affect the absorption of codeine; it can be a problem in the enzyme metabolizing the painkiller after entering the bloodstream, or the transporter protein – the vehicle needed to carry the drug to wherever in the body it is needed. Any drug hanging around in the brain for longer than intended can cause severe problems, such as nausea, breathing difficulty, or death. Testing our susceptibility to what could be interpreted in layman's terms as a non-dangerous drug is of major benefit to the NHS.

However, Professor Munir Pirmohamed, head of the University of Liverpool's department of pharmacology and NHS chair in pharmacogenetics, is quick to point out that "not all drug reactions are because of genetics – it could be related to whether the patient took it properly, or was smoking or drinking – but if we can disentangle those other causes from the genetic causes, if we can reduce adverse drug reactions by 30% through genetics, it will have a major impact on the NHS."

Bad or ineffective drug reactions, potential or present, have proved to be much more difficult to pinpoint than originally thought. A biomarker – or genetic marker – is part of a DNA sequence that is associated with any genetic variant different to the norm. The mapping of human genomes involves three key phases: sequencing, assembling and annotating. Human DNA building blocks (A, C, G, T) have been revealed and assembled correctly, but it's in the annotating that the real difficulties begin. Identifying which gene does what by sorting through billions of letters of identical code for a single reversed A-C pair could be the answer to why one person suffers cancer and another doesn't – or it could not.

By identifying which gene variant is responsible for disease, medical treatment will be individually tailored. With a few exceptions, this stage is still in development. The complex gene-lifestyle relationship heightens the difficulties faced in testing for biomarkers. Recent twin studies at the University College of London shattered common preconceptions: more than 50% of back pain but fewer than 25% of cancers are inherited; behaviour and personality traits such as perfect pitch and a penchant for crime are more genetically predetermined than environmental. It is a confused picture.

Not surprisingly, variations that occur on a single gene such as cystic fibrosis and Tay-Sachs disease are much easier to identify than hypertension and type II diabetes – diseases that arise because of any number of gene-gene, or gene-environment, interactions.

The advent of consumer genetics providers – companies such as 23andMe and deCODE Genetics – occurred following the publication of the human genome. Users submit a saliva sample and are presented with a copy of their personal genome and information about their genetic predisposition to about 100 different traits ranging from Alzheimer's disease to nicotine dependence. A sign of the times was the advent of "spit parties", where dinner guests sampled their DNA alongside their dessert.

But as the hype around the present reach of personal genetics gradually lessened, the business underwent subtle rebranding from consumer research companies. If you present your GP with a printout of your personal genome stating a 60% chance of developing Alzheimer's is present, your doctor probably won't have any idea what you're on about.

"Alzheimer's is a particular variant," says Brice, "known to be significant enough to make a safe assumption that the biomarker is correct. So scientifically, it's valid – but what are you supposed to do about it? They might make a more detailed report, but there is nothing that can be done right now to prevent you from developing it."

In future, the one-size-fits-all approach to drug treatment will seem positively archaic: anti-cancer drugs with response rates of just 20% are "effective", while major drugs are killed in final stages because they don't clear the "average" benchmark of 35%, despite having an excellent response in, say, 30% of people. We've got far fewer genes than first anticipated, but this isn't good news; the surprisingly low number of genes that make up a human body (about 35,000) means that how they work is a lot more complicated than first thought.

Ninety per cent of early clinical trials by Eli Lilly, Pfizer and Bayer now include strategies to test for the possibility of predictive gene variants. Improving technology and speed and the rapidly falling cost of whole-genome mapping will ease the burden of testing for individual genes such as cystic fibrosis. And as it becomes a natural part of medical care, we're less inclined to anticipate the future ahead of schedule.

Barbara Prainsack, professor of sociology and politics of bioscience at Brunel University in London, says: "Personalised medicine is pointing to a larger shift in the way we think about health and medicine. We're no longer in the era where pharmaceutical companies are bad and patients are passive. Personalised medicine can now be organised, or reorganised to align the competing interests of financially motivated companies and patients." Currently, genetic data is treated more guardedly than personal medical data, despite the ease with which medical records can be deciphered.

Much of the non-technical work being done now for the future of personalised medicine is anticipating the social implications that may arise from having potentially fatalistic information at our fingertips. "People are unduly worried about genetic information," says Brice. Patients undergoing testing for one thing may discover an entirely worse fate when something else is discovered. "Genetic medicine won't replace normal medicine, but there are worries about finding things you weren't looking for. How do you get around that?"

The European Science Foundation and PHG Foundation are both set to publish major works on the future of personalised health care in coming months. While perfectly tailored medical treatment is probably 50 years away, perhaps it is promising that the social implications are being simultaneously, pre-emptively tackled.