Fingerprints, profiles and investigations: metabolomics under the spotlight

We are very familiar with the fact that fingerprints left behind during a crime form critical evidence in crime scene investigation. They allow forensic experts to find out who was present at the crime scene and assist in interpreting what happened during that crime. Just like evidence is left behind after a crime, evidence is also left behind when our cells, tissues and bodies go about their daily processes (metabolism). A metabolic fingerprint or profile can help scientists interpret what is going on inside our cells, tissues and bodies, and help them identify why things may be going wrong when we are ill.

Scientists can find a lot of evidence for what is going on inside our bodies in body fluids such as blood and urine. That is because blood carries products of metabolism away from the tissues and excretes it in the urine. The products or intermediates of metabolism are called metabolites and the total collection of metabolites is called the metabolome. The name given to studying the metabolome is metabolomics.

Metabolomics is defined as the study of the unique chemical fingerprints that specific cellular processes leave behind. The metabolome is dynamic and changes from second to second. Metabolomics can give more information about what is going on in a cell in an instant snap shot than genomics (looking variations in genes) and proteomics (looking at protein patterns) can give on their own. When scientists are able to look at all three areas, they will get a complete picture of what is going on in a living organism.

Since ancient times, doctors new that blood and urine could tell a lot about the health of a patient. For example, ancient Chinese doctors used ants to tell whether a patient had diabetes because they were able to detect high concentrations of glucose in urine. Colours, tastes and smells of urine were used to diagnosis various medical conditions.

The concept of metabolic profiles characterised in biological fluid was introduced in 1940's. Technology advanced in the 1960's and 1970's to measure metabolic profiles, through Gas Chromotography Mass Spectroscopy (GC-MS). In the 1980's Nuclear Magnetic Resonance Spectroscopy (NMR) became sensitive enough to identify metbolites in biological samples. In 2007, scientists completed the first draft of the human metabolome. They catalogued approximately 2500 metabolites, 1200 drugs and 3500 food components that can be found in the human body, as reported in the literature. There is still, however, a lot of work to be done in understanding the human metabolome.

Scientists are particularly interested in certain very small metabolites, known as low-molecular-weight metabolites. These include amino acids, sugars, carbohydrates, and lipids, and they can provide important clues about a person's health. By studying the changes and concentrations of these small metabolites within the body's cells, scientists can find unique patterns (profiles), which change when the body is fighting a disease, reacting to a drug, or responding to another form of stress. Because the metabolome is influenced by disease, metabolomics can be used not only to diagnose a disease but also to monitor its progress. It offers a way to measure effectiveness of a drug through "improvement" in metabolic profile.

Metabolic profiing can also be used in assessing toxicity, by seeing what changes are caused by a toxin, which may relate specifically to damage to a specific organ such as the liver or kidney. This is useful for pharmaceutical companies testing a drug to eliminate toxic drugs before the expense of going through a clinical trial.

The Metabolomics Platform at the University of the North West (NWU), with funding from the Technology Innovation Agency (TIA) and under the leadership of Prof Carools Reinecke, is looking at the metabolic profiles of inherited disorders of metabolism, particularly in children. Part of this study is to establish the normal range for the human metabolome within the South African population to standardise the metabolome of metabolic disorders and provide reference. There are approximately 2000 metabolites characterised and documented to date. This also allows the possibility to investigate beyond inherited metabolic disorders to, for example, the metabolome of pathogenic organisms and other diseases relevant to major health problems in South Africa. Metabolomics promises to have a major impact in addressing some of the health challenges faced both in South Africa and internationally.