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Environmental medicine and biosensor technology

Smog, chemicals in rivers, particular matter from copying machines in offices – human beings are exposed to many toxic influences. Environmental medical specialists are investigating the effect that these kinds of substances have at the same time as trying to find ways to reduce their influence on human health as much as possible. Molecular and cell biologists and even biotechnologists all have a key part to play in these efforts. On the one hand, they particpate in the investigation of the biological effects of environmental toxins on the cellular and molecular levels. On the other hand, they develop tools – so-called biosensors - for the early detection of environmental toxins.

Agriculture suffers because of industry.
© Roger Griffith

Industrialised societies have been responsible for polluting the human environment in many different ways. Polluted groundwater can have direct and indirect effects on human health - directly through the consumption of drinking water or indirectly through agriculture and the food industry. Polluted soil can cause diseases: Dog excrements in children's playgrounds are the major source of infections in cities. Heavy metals and other toxins in industrially polluted agricultural land enter the human food chain. Smog pollutes the air we breathe. Further negative influences on human health include irradiation (for example radioactivity) or the climate (increase in infections due to floods). However, harmful effects on human health do not only happen in the "great outdoors", but also inside and from buildings.

Home sweet home and other traps

Medicine has for a long time concentrated on harmful influences occurring in the “great outdoors”. However, human beings spend a major part of their lives inside buildings. Apartments, houses, offices and industrial space can all release harmful substances that can lead to cell damage. Whether it be passive smoking in restaurants, mould in damp apartments, cat hairs that cause allergies or toxic particular matter from copying machines and printers in offices – it is becoming increasingly obvious that it is high time to look at human environments that have previously been regarded as safe. Allergies, cancer, infections caused by moulds, bacteria and viruses or lung diseases caused by dust are becoming increasingly common. As are disorders of the human nervous and hormone system.

Flue ash isolated from the air is found in the smoke emanating from combustion plants or car exhausts and it affects the cells of human lungs.
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The investigation of cells and tissues provides increasing evidence of the harmful effects that exposure to environmental toxins can have on molecular processes. Heavy metals in soil and groundwater can interfere with the structure of enzymes. Chlorated hydrocarbons, such as those used in varnish and dye solvents, can lead to DNA modifications and eventually, cancer. Antibiotics that enter the human food chain through pigs and chickens, can lead to resistances in human pathogenic bacteria, making them more aggressive. Substances emitted by combustion engines and combustion plants (for example dioxins, which also includes the defoliant Agent Orange) affect

cellular signalling cascades and alter the activity of genes, thus interfering with the balance between key enzymes. This in turn can have an effect on hormonal balance and the human nervous system.

However, the environment can also have positive effects for human beings: many scientists are searching for natural secondary plant substances that might be able to induce the apoptosis (cell death) of cancer cells and hence slow the growth of tumours. An important example of such substances is the isothiocyanates found in cruciferous plants such as rocket.

Environmental monitoring

Environmental medical specialists can establish environmental monitoring processes for the early detection of harmful influences. One of the first examples of such monitoring was the use of canaries to alert mineworkers to the lack of oxygen in the air. Modern systems can also be used to identify potential pollutants, as the toxic effect of substances is often unknown. The field of biosensor technology has established itself at the interface between biology and microsystems technology as a useful instrument with high innovative potential. Biosensors are measurement systems established with biological components that interact with an environmental toxin and create a biological signal. An integrated transducer converts this signal into data that can then be interpreted.

For example, scientists grow cell lines that are sensitive to environmental toxins. These cell lines indicate whether a certain chemical interferes with processes such as growth, cell division or migration. Biotechnology also makes a contribution to these efforts: Genetically modified bacteria can produce a fluorescent protein when exposed to a high concentration of arsenic. In this case, a protein that binds arsenic and subsequently increases the activity of a gene that normally induces countermeasures against arsenic intoxication in these bacteria, acts as biosensor. Scientists couple this particular gene to a "fluorescent gene" (luciferase for example). When the bacteria that contain this gene construct are exposed to arsenic, the luciferase gene is activated along with the "protection gene" and starts to fluoresce. The fluorescent signal can be seen under the fluorescence microscope and can be used to assess the quantity of toxic heavy metals to which the bacteria are exposed.

Biomolecules such as nucleic acids, enzymes or antibodies can also be used as biosensors. When they react with a certain substance, such molecules change their structure or activity. Scientists can then determine what changes occur. Molecules of this kind are already being applied to biochips and used for tests. In contrast to chemical test methods, biosensors have a particular advantage when it comes to environmental issues: drinking water, soil and air samples contain a large number of different chemicals. Not all of these substances are toxic. Biosensors often react very specifically to certain molecules, which makes them very useful in the search for the "needle in the haystack".

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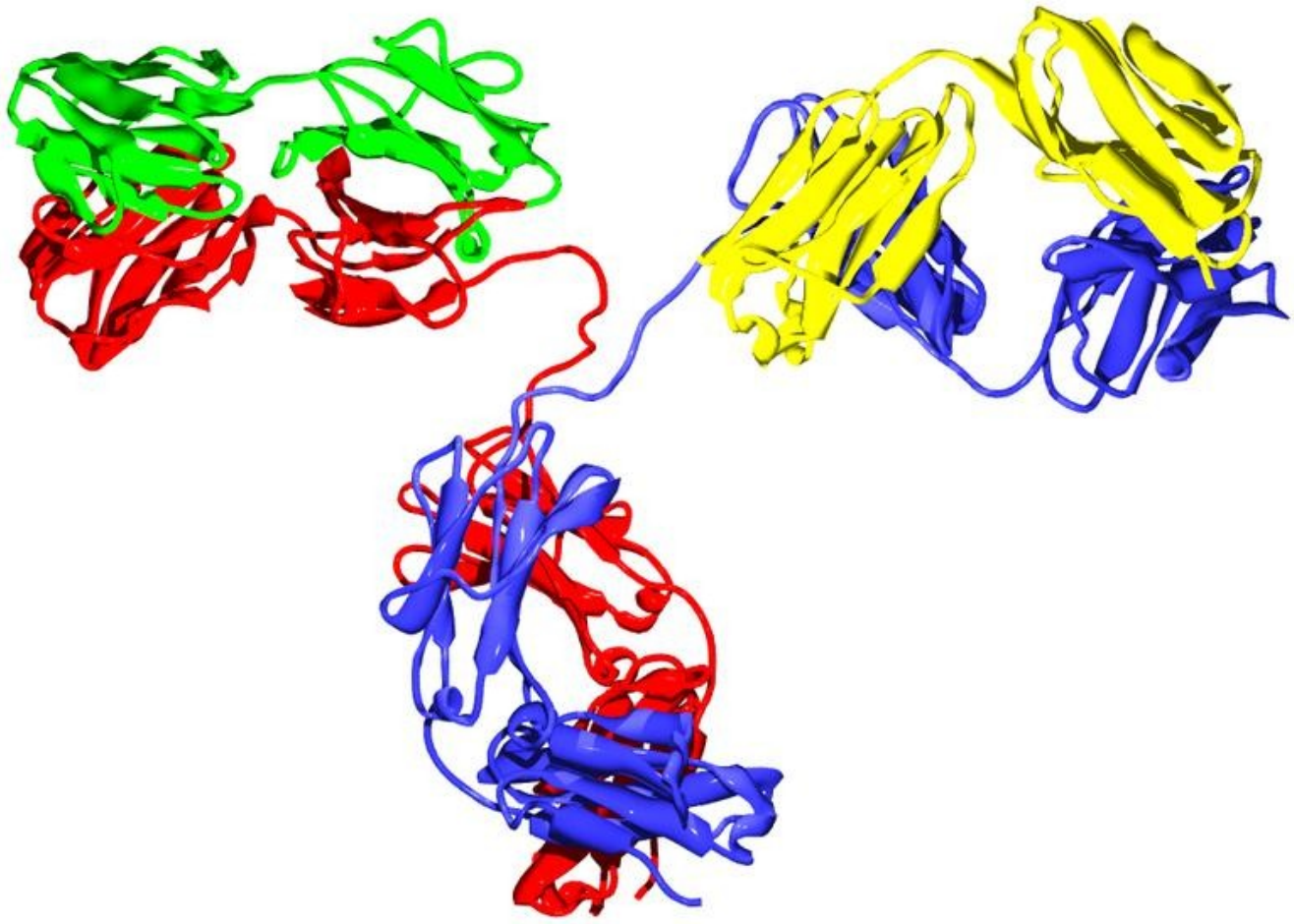

Antibodies can specifically bind foreign substances. Scientists are able to measure this, which is why the molecule is well suited as a biosensor.

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