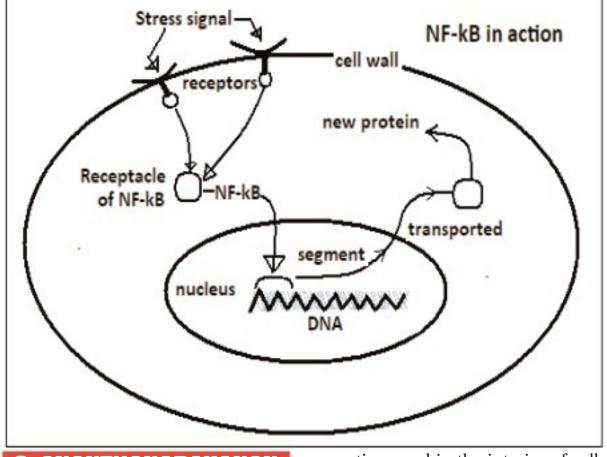# Delving into the
DNA

Mind-body interventions like yoga, pranayama, Tai Chi and meditation, are found to take charge of processes in the nuclei of body cells

Sharanya Narayanan - Yoga trainer

NF-kB in action

Ivana Buric   Miguel Farias   Jonathan Jong   Christopher Mee   Imti A Brazil

S ANANTHANARAYANAN

Many practices and traditions, mostly in the orient, combine physical and mind control disciplines. These practices are known to bring about calmness, reduce anxiety and the perception of stress, relieve depression or help people cope with chronic disease. While these methods are associated with control of hypertension, insomnia, arthritis and many stress-induced conditions, the mechanism by which the reported benefits arise has not been understood.

Ivana Buric, Miguel Farias, Jonathan Jong, Christopher Mee and Inti A Brazil, working in Coventry University, UK, Radboud University, Nijmegen, Netherlands and Antwerp University, Belgium have looked into how these practices may affect the body at the cellular level. Their report, in the journal, *Frontiers in Immunology*, finds that mind-body interventions suppress the presence of a main factor that is known to facilitate the reaction of cells to stress, which leads to inflammation-related conditions.

While there have been studies of the effects of MBI on the parts of the brain that control things like emotions, learning and memory, these have not been conclusive, the paper says. However, powerful techniques to study how genes, or portions of the genetic record in the interior of cells become effective, are now available and there are several reports of analyses of gene expression and MBI research, the paper says.

The centre, called the nucleus of living cells, contains a long, chain molecule, the DNA, which consists of millions of segments. Each segment contains the code for the assembly of a unique protein. Some proteins go to make up body tissue, like muscle tissue, or hair or skin. Others, like haemoglobin, can play a role almost like an organ, which has a specific function. And yet other proteins are messengers that go from cell to cell or from one part of a cell to another, to start or stop things that the cells do.

As proteins have complex and unique shapes, or profiles, they can act as very secure "keys" to fit specific "keyholes" in cells, to set in motion various sequences, including the release of other proteins. When cells create proteins, the method is that a part of the DNA, the part that codes for that protein, is copied and transferred to another part of the cell where the protein is assembled. One group of messenger proteins, the transcription factors, specialise in setting in motion the process of copying a part of the DNA, for creation of proteins.

A study of the effect of individual genes, however, is not feasible, as there are so many and because genes generally work, not by themselves, but in in groups. Genes are hence studied using statistical methods and computer controlled artificial intelligence systems, to identify which ones are associated with the same pathways and related functions.

In the context of research on MBIs, the paper says that the most studied transcription factor, or the protein that sets in motion the process of protein assembly, is one called nuclear factor kappa B (NF-kB). This factor gets released when the organism is stressed, to set in motion the "self-defence" processes in the cell. NF-kB is found in almost all kinds of animal cells and the stress could be the presence of the so called, "free radicals" (which are suppressed by antioxidants), heavy metal poisoning, ultra violet radiation, responses to bacteria or viruses or other stress signalling proteins.

When the messengers that signal attack or danger make contact with the cell, NF-kB — a "rapid acting" transcription factor, because it is there in the cell and need not be generated — gets released . The cells respond by releasing proteins that bring about inflammation. These proteins set in motion a "cell survival" response or could lead to cell proliferation, to combat the threat. And to prevent run-away cell response, NF-kB also sets in motion a substance that suppresses NF-kB itself, to turn off the emergency alert.

Errors in the regulation of NF-kB, however, can lead to continued inflammation, and this leads to auto-immune diseases, where the body attacks itself, like bowel disease or arthritis. As NF-kB brings about replication of cells, it can cause cancers and it even encourages some viruses to multiply. While the release of NF-kB helps the body cope when there is a threat or challenge, modern living often creates continuous stressful conditions and excess release of NF-kB. "Chronic inflammation is associated with increased risk for some types of cancer, neurodegenerative diseases, asthma, arthritis, cardiovascular diseases, and psychiatric disorders," the paper says.

As MBIs are known to help stressful conditions, there is a hypothesis that MBIs can turn around, or reverse, the expression of genes involved in inflammatory reactions that are induced by stress, the paper says. To see if this actually happens, the researchers reviewed available information about the changes in gene expression that occur when persons undertake MBI practices. World-wide publications were scanned and 716 articles were identified and analysed, to be left with 18 studies and 846 participants, which were statistically reliable.

The MBI practices studied include Asian Qigong (reading of texts and light physical practice), sudarshan kriya (yogic breathing practice), pranayama (breath control), kirtan kriya meditation, Tai Chi, Iyengar yoga (a form of Hatha yoga with emphasis on precise alignment and breath control in each posture), Relaxation Response and Mindfulness practice.
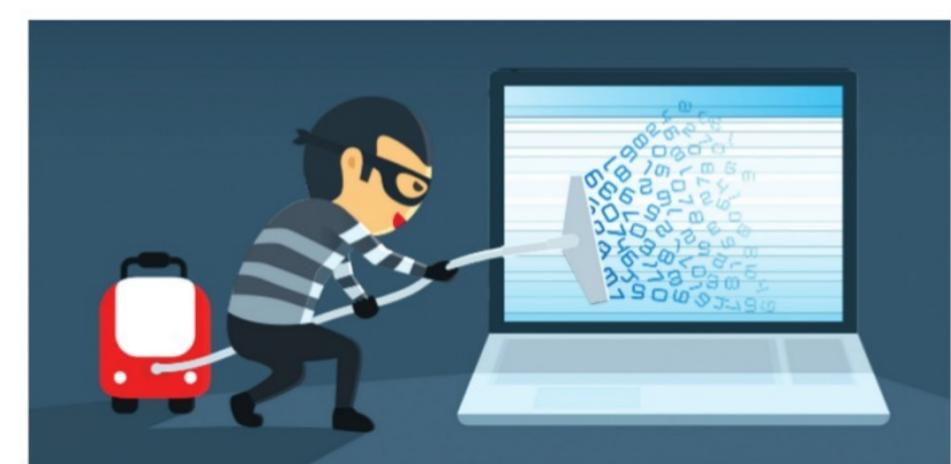
The studies were carried out by creating groups of practitioners of the MBIs, along with groups of comparable persons who did not practice the MBI. Which genes were active in different types of cells in the two groups was then ascertained. A study with Qigong, for instance, used neutrophils, the most common type of white blood corpuscles, which are crucial in the defence against infection —12,000 genes were studied and it was found that 132 genes were suppressed and 118 were promoted. "Some of the differentially expressed genes have common functions, which suggests that Qigong enhances immunity, down regulates cellular metabolism, and delays cell death," the paper says.

Studies with sudarshan kriya, pranayama, yogic meditation, mindfulness and Tai Chi led to similar results. One study explored the effects of three months of Iyengar yoga on inflammatory processes in breast cancer survivors with fatigue — 282 genes were found to be promoted and 153 were suppressed in the yoga group, as compared to the health education control group. The majority of the genes suppressed were the ones associated with fatigue in cancer patients. Iyengar yoga was found both to reduce the activity of NF-kB, the key regulator, and to increase the activity of cell features that reduced inflammation.

One study was with patients of Irritable Bowel Syndrome and Inflammatory Bowel Disease. The researchers explored the value of Relaxation Response — breath focus, imagery, mindful awareness, and yoga. They found that nine weeks of hour-long weekly sessions with 20 mins of daily home practice brought remission of pain and anxiety and a rise in the quality of life. In the IDB group, 1059 genes were found to have changed — and these were related to improvements in inflammatory response, cell growth, multiplication of cells, and the effect of oxidising "free radicals". Another 119 genes were related to cell-cycle regulation and DNA damage.

The authors caution that the studies are still not exact and do not deal with the possible effects of other factors, like diet, sleep, exercise or environment. However, "the results of 18 studies that used gene expression analysis in research on meditation and related MBIs have overall found down regulation of NF-kB-targeted genes, which can be understood as the reversal of the molecular signature of the effects of chronic stress," the paper says.

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Breaking & entering

Cyber security wake-up calls, like the recent WannaCry outbreak, point to a patchy response to known technical problems

JOHN A CLARK

The National Health Services' recent WannaCry ransomware ordeal is the latest in a series of cyber incidents that have habitually come to be described as a "wake-up call." One might believe that a cyber wake-up call should result in behaviours that improve security. So does this happen and what are the prospects for countering future malware?

Despite persistent advice to users much malware is still contracted via "explicit user action", like clicking on a web link causing a browser to download malicious code and run it with the user's privileges or inserting compromised USB sticks into the system. Take-up of security behaviour advice seems patchy and effectively communicating good cyber hygiene practices across diverse user communities remains a major challenge.

Many contracted infections are plainly avoidable. Anti-malware, for example, does a good job but isn't always deployed. The WannaCry incident revealed how obsolete and unsupported operating systems such as Windows XP continue to be operated in major organisations but Microsoft had fixed the problem for its more modern supported operating systems.

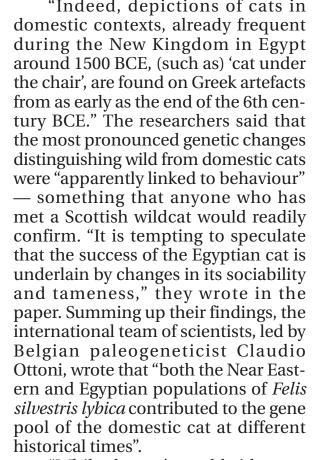Application software is also persistently problematic, with the most common application vulnerabilities seeming to be implemented time after time. Injection attack vulnerabilities, for example, regularly head or appear in Owasps' top10 list. Here inputs are carefully crafted to cause security breaches. For example, a hacker claiming to be *john* supplying a decidedly odd password string of characters *wrong_password OR '1'='1* to an authentication system may cause that system to form a database query along the lines of *STORED_PASSWORD[john] =wrong_password OR '1'='1*?

From a security point of view this should be interpreted as "Is the input string *wrong_password OR '1'='1* equal to the stored password for user *john*?"However, a typical database may interpret this as "Is the stored password equal to *wrong_password, OR is 1 equal to 1*"? Since 1 is equal to 1, the authentication system returns TRUE and the hacker will be logged in. There are many such database injection attacks (the above among the simplest) with a range of corresponding countermeasures.

Input validation — checking for malicious input crafting — is a widely recommended countermeasure against many. Nevertheless, developers continue to build systems with plainly avoidable database injection vulnerabilities. Similarly, careful choice of supplied parameters to a software function or procedure can violate memory constraints on the system and cause specific areas of memory to be overwritten with supplied data that contains arbitrary malicious code. With skill, this code can be located appropriately to ensure subsequent execution. Such "buffer overflows" are well-known and there are well-understood means of countering them. Yet they occur as major vulnerabilities year on year. Educating a wider application developer base remains a critical task.

We seem to have a patchy record on countering known technical problems. The above gives just an indication. So what of the future?

Some modern viruses and worms may radically change the way they and their progeny "look" — by reformulating themselves and using encryption to evade detection of characteristic structure. These polymorphic malware use such shape-shifting to evade the detectors (which typically look for characteristic patterns). However, the behaviours of instances of such malware will often constant or very similar. This means that there will be a shift to detectors that monitor behaviour rather than form. However, constant behaviour is not essential and malware can always vary its behaviour to evade detection.

Some malware may remain difficult to detect. Detection of malware using a "covert channels" (one which uses the very existence or non-existence of a file to signal one bit of information) may be a rather difficult affair, particularly when required through put may be extraordinarily low — leaking a 256 bit crypto key at the rate of one bit per hour would take 11 days but the key may have vast significance. The low bandwidth will likely evade detection.

Detecting previously unseen malice and malware will remain a major technical goal. Provided new malware itself has characteristics similar to previously identified malware, behaves in a similar way, or has similar effects on the system, then technology for detection of new malware and attacks has some hope. But a new attack may exhibit none of these.

The deep integration of computation into the fabric of our increasingly smart society presents further challenges. The Internet of Things, with its major interconnectivity of diverse components, will create a vastly increased threat surface.

Furthermore, we are increasingly seeing systems for which safety depends on security. Imagine a moving car or in-use operating theatre system discovering it has been compromised by malware. What is it to do? Dealing with discovered compromise here may require considerable technical subtlety.

Finally, we have already glimpsed the probably inevitable rise of the resource rich malware developer. The Stuxnet worm targeting Iranian nuclear re-processing centrifuges around 2010 used four previously unseen vulnerabilities, a substantial resource indeed. Some have estimated the development cost of Stuxnet as several million dollars, with state involvement suspected by some. The recent WannaCry ransomware attack that hit the NHS exploited a vulnerability (Eternal Blue) discovered originally by the US National Security Agency. It is clear that various nation states are capable of deploying considerable resources to develop malware. This perhaps will have the greatest effect of all.

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Mars concept vehicle

Nasa has unveiled a new Mars rover concept vehicle designed to function "as both a working vehicle and laboratory" for the next generation of space explorers. The 8.5-metre vehicle would not look out of place in a science-fiction film. It features six huge wheels to allow it to travel over craters, dunes and rocks, a sloping front reminiscent of the Nolan-era Batmobile and solar panels to power everything.

"It features life support systems, navigation and communication systems, and design and materials that relate to conditions and resources on Mars," Nasa said.

Created by Parker Brothers Concepts, the rover — which looks nothing like the actual vehicles that have trundled over Mars' surface, 34 million miles away — will promote Nasa's "summer of Mars" to teach young people about its efforts to land humans on Earth's neighbouring world.

The concept vehicle will never cruise the dunes of Mars but Nasa believes "one or more of its elements could make its way into a rover astronauts will drive on the red planet". The space agency's next robotic rover is due to touch down in 2020, to "search for signs of past microbial life and collect core samples for a potentially future return to Earth".

John sharman/the independent

The cat's conquest

The domestic cat has proved to be one of the most successful animals on the planet, managing to capitalise on its close relations with humans to colonise every continent except Antarctica.

Now scientists have discovered that many of today's *Felis silvestris lybica* are descended from cats which lived thousands of years ago in Ancient Egypt.

Using genetic analysis, the researchers established that cats were first domesticated in the Near East about 10,000 years ago, probably by farmers because of feline skills in dealing with mice and other rodents that raid grain stores. A complete cat skeleton dated to 7,500 BCE was found associated with a human burial site on the island of Cyprus. However, it was not until several thousand years later that cats really began the journey that would take them to every corner of the globe.

In Ancient Egypt, cats and humans developed a remarkably close relationship as shown by numerous depictions in art from around 2,000 BCE. "The increasing popularity of cats among Mediterranean cultures and particularly their usefulness on ships infested with rodents and other pests presumably triggered their dispersal across the Mediterranean," the researchers wrote in the journal, *Nature Ecology & Evolution*.

"Indeed, depictions of cats in domestic contexts, already frequent during the New Kingdom in Egypt around 1500 BCE, (such as) 'cat under the chair', are found on Greek artefacts from as early as the end of the 6th century BCE." The researchers said that the most pronounced genetic changes distinguishing wild from domestic cats were "apparently linked to behaviour" — something that anyone who has met a Scottish wildcat would readily confirm. "It is tempting to speculate that the success of the Egyptian cat is underlain by changes in its sociability and tameness," they wrote in the paper. Summing up their findings, the international team of scientists, led by Belgian paleogeneticist Claudio Ottoni, wrote that "both the Near Eastern and Egyptian populations of *Felis silvestris lybica* contributed to the gene pool of the domestic cat at different historical times".

"While the cat's worldwide conquest began during the Neolithic period in the Near East, its dispersal gained momentum during the Classical period, when the Egyptian cat successfully spread throughout the Old World," they said.

Ian johnston/the independent