

AND THE REMWARD GOES TO YOU!

When we run, our brains make it worth our while, which is why we come back for more



WORDS: Sam Murphy

FEEL-GOOD FACTOR

EVERY DAY IN JANUARY, ANNE CATT GOT OUT OF BED TO RUN IN THE COLD, THE DARK AND THE FROST.

After I run, I feel like everything is a bit more right with the world,' says the East Sussex runner. 'It sets me up for the day.'

Few feelings rival that post-run glow – a sweaty mingling of satisfaction, joy, calmness and clarity. It's one of the reasons we run. Even when no one else is up. Even when it's raining. But can you remember your very first run? The way alarm bells changed throughout your body within minutes. The way your lungs declared breathlessness, your bones complained of jarring, your skin pricked. The way you felt everyone was looking at you, and you could only marvel at runners you saw chatting and laughing, seemingly enjoying the experience.

Catt hated running when she started, five years ago. 'I was recovering from a very profound depression and I knew that exercise was one of the things that was meant to help. But I didn't enjoy it,' she says.

It's a wonder Catt's – or any of our – running shoes were laced up a second time, or a third. Especially when you consider that, like all animals, our natural instinct is to conserve energy, not expend it.

'No sensible adult hunter-gatherer would waste 500 calories running five miles just for kicks,' says Daniel Lieberman, professor of human evolutionary biology at Harvard University and author of *Exercised: the Science of Physical Activity, Rest and Health*. 'Gratuitous physical activity would reduce how much energy you could devote to the key tasks of survival and reproduction.'

It's strange hearing this from the author of a seminal paper published in the journal *Nature* in 2007, which argued that our ancient ancestors evolved specific adaptations to make them efficient endurance runners – that we were born to run' in order to forage, track prey and reach carrion ahead of predators. But here lies the paradox. 'We only moved when it was necessary or rewarding,' says Lieberman. 'The same holds true for hunter-gatherers today. David Raichlen, a professor of human and evolutionary biology at the University of Southern California, has spent time with the Hadza people in Tanzania, one of the last remaining hunter-gatherer tribes in the world. 'It's amazing how active they are and amazing how *inactive* they are,' he says.

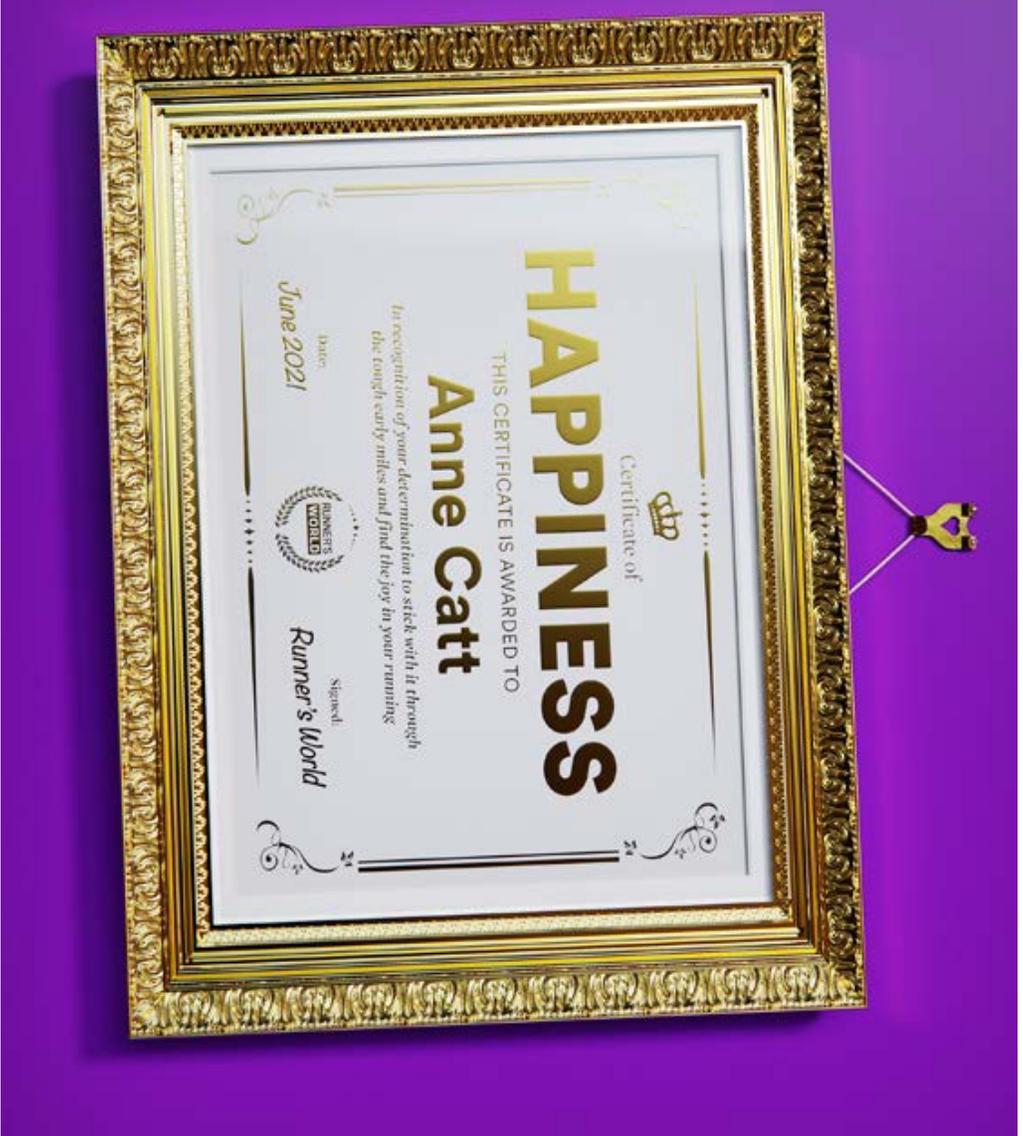
'When I told them what I did on a daily basis – get up before dawn and turn a loop from my home, without looking for food – they thought I was crazy. If you don't have to move, why would you? It's expending energy for no reason. For hunter-gatherers past and present, running is far from gratuitous – it's a necessity for survival. It's for this reason, believes Raichlen, that our brains came up with ways of making the experience more palatable.

CHEMICAL REACTION

CATT TOLD ME she gets a runner's high every time she goes out. 'I have to confess that in three decades of running, I've rarely reached the lofty heights some runners describe, likening the feeling they get to love, intoxication or a spiritual experience. I tend to feel pleased, rather than ecstatic. But it's still a pleasurable buzz, and we have our brains to thank for that.

'The brain can manufacture an impressive cocktail of pharmaceuticals in response to physical activity that affect mood and brain health,' says Lieberman. It's likely you've heard of endorphins – pain-numbing, pleasure-producing opiate-like chemicals our bodies produce in response to exercise. They're probably part of the picture, but newer research has debunked the theory that endorphins are the sole – or even main – contender in making exercise feel good. In a German study published earlier this year, a drug called naltrexone was used to block opioid receptors (so endorphins could not exert an effect) while people ran for 45 minutes. Despite the absence of endorphins, the runners still experienced feelings of euphoria and a reduction in anxiety, suggesting that endorphins didn't play a significant role in creating a runner's high.

So what did? 'In our study, we found elevated levels of endocannabinoids after running,' says Johannes Fuss, one of the study authors. 'This builds on research on mice, which found molecules called endocannabinoids (ECBs) played a role in making exercise pleasurable. And in a recent study from the University of Wisconsin-Madison, US, people with depression who were ►



Lucky in love

Are some people more genetically predisposed to enjoy running than others?

It's long been known that genes play a role in sporting prowess, but some research has suggested our genetic make-up may play a role not just in our capacity for exercise, but also our inclination.

Behavioural Brain Research identified four genetic variations that influenced the reinforcing value of exercise (how much reward someone derives from exercise, which reinforces further participation) and tolerance of exercise intensity, leading researchers to conclude that there is a genetic variation. Genes alone are unlikely to stop anyone falling for running, though. 'Some of us may have inherited tendencies to be slightly less inclined to exercise,' says Lieberman. But no common genes have been identified that explain more than a small percentage of the variation in activity.

However, it is well worth remembering that your DNA has made you an experiment of one, and what works best for you may be different from what works for others. 'It is clear that people have individual differences in what type of movement draws out the most powerful reward and reinforcement,' says McGonigal. 'It might be being out in nature, it might be moving with others, it might be HIIT training or moving to music.'

'Blues seem bluer. I remember having an intense high during the last miles of the London Marathon – I was running past Big Ben thinking, "Wow! Big Ben is so big!" Lieberman believes such heightened perception would have been beneficial to our hunter-gatherer ancestors.'

One thing's for sure, though: you have to put in some effort to reap these rewards. 'We found no euphoria in walkers, even though there was a small rise in their eCB levels,' says Füss. 'We concluded that there must be a certain threshold of eCB release needed to have an effect on mood.' Studies have found mood-boosting benefits from workouts lasting 20 minutes to two hours. 'We don't know an exact dose, but the key is probably achieving a moderate intensity over some time,' says Ratchalen. In research he conducted in 2013, getting a 'high' was intensity-specific. 'It wasn't triggered by either very high intensity or very low intensity exercise.' This, he speculates, may be because moderate, prolonged exercise is the nature of the activity at which we evolved to excel.

'Looking at the evidence, it's hard not to conclude that our entire physiology was engineered to reward us for moving,' says Kelly McGonigal, a research psychologist and author of *The Joy of Movement*. But there's a problem. Because movement was an integral part of life, our brains developed the activity-reward connection within the context of a fit, healthy body. Studies have shown that a number of factors, including inflammation, stress, obesity, depression – and inactivity itself – can dampen the activity of neurochemicals such as dopamine, serotonin and eCBs.

'The people who most need the medicine of movement are the least likely to get a high when they first exercise,' says McGonigal. 'The brain needs to learn

'The brain reads movement as a positive sign – one that says you are engaged with life'

how to reengage with the reward system.' (See *Hope for the joyless runner*, p48.) Talking about her own experiences of becoming a committed exerciser, she says: 'I like to think my brain understood that a positive transformation was underway. Something deep in my DNA recognised a good thing and said "Yes, thank you, keep going!"'

Evidence backing her theory that our bodies are grateful when we step up our activity level even when we may not consciously be aware of it comes from real-time mood- and physical activity-tracking studies, which monitor what you're doing and how you feel throughout the day. One such study, with 10,000 subjects, found that people report being happier in those moments when they are moving than when they are sedentary. 'Your mood is basically a read-out on your reality, based on whatever information your brain is processing,' says McGonigal. 'The brain reads movement as a positive sign – one that says you are engaged with life.'

It took almost two years for Catt to enjoy running. 'I'd feel relief afterwards, and be pleased that I'd achieved something worthwhile and positive, but I didn't like it,' she admits. 'It wasn't until I was training for my first half-marathon that it suddenly realised I was enjoying myself. Now I can't imagine life without it. It's my happy place.'

Like all of us who grow to love running, Catt's internal reward system has undergone a training effect. 'You wouldn't expect your heart to perform at its peak on your first run, but over time, it adapts and gets fitter,' says McGonigal. 'The same is true of the brain. As you become more accustomed to exercise, you get a greater release of the feel-good chemicals and then you also get more receptors for them. The brain learns how to produce a high more reliably and more strongly.'

But it's not all about chemicals. 'We get rewarded not just by how exercise feels, but by what it means,' says McGonigal. 'This brings us neatly back to Lieberman's point about physical activity needing to be necessary or rewarding. By finding ways to make running one or the other – or, preferably, both – we cement our relationship with it.'

Ratchalen, who is a keen runner, believes the buzz he gets from high-intensity exercise is less to do with neurochemicals than what he calls ►

prescribed moderate-intensity exercise showed elevated levels of eCBs and experienced improvements in mood.

But there are plenty more mood-boosting substances in the brain's chemical cocktail cabinet. Alongside endorphins and eCBs, a study in the journal *Brain Plasticity* reports changes in levels of dopamine, serotonin, noradrenaline, acetylcholine, gamma-aminobutyric acid (GABA) and glutamate in response to exercise. Many work together – for example, says Füss, eCB signalling also stimulates the release of dopamine into the brain's reward system.

Dopamine is released in response to reward-yielding behaviours, such as eating tasty food, having sex or running. 'This molecule tells a region deep in the brain "do it again",' says Lieberman. Dopamine helps reinforce healthy behaviours, and is part of the reason that you go from dreading running to craving it. But it can get hijacked by unhealthy behaviours, such as addiction.



Signed,
Runner's World

Serotonin is another neurotransmitter released in response to exercise. The mood-regulating molecule is a target of many anti-depressant medications. It's also involved in memory and learning, particularly impulse control – the capacity to suppress inappropriate behaviour.

Cortisol, most commonly associated with stress, is also released when we begin to exercise. That might not sound positive, but studies show an exercise-derived elevation in cortisol helps us handle subsequent stress with greater equanimity – that satisfying 'sets me up for the day' feeling.

Then there's GABA, increasingly being found to play a role in quelling anxiety; brain-derived neurotrophic

CGI ILLUSTRATIONS: PETER CROWTHER

factor (BDNF), associated with brain growth and repair; in short, a whole host of compounds saying yes, yes, yes to exercise. But why?

'It's the ultimate question,' says Ratchalen. 'From an evolutionary standpoint, these neurobiological rewards may have motivated us to move in order to increase our chances of survival and reproductive success. Alternatively, given that many of these compounds reduce pain sensitivity, it could be that their role was to reduce the pain associated with movement and that their feel-good effect is just a happy accident.'

Lieberman has another theory. 'A runner's high enhances sensory perception and awareness,' he says.

'higher cognition'. 'That feeling of accomplishing something challenging, the sense of mastery and self-efficacy.'

McGonigal agrees. 'Physical accomplishments can challenge and change how we think about ourselves and what we are capable of,' she says.

Of course, over time, exercise also becomes entrenched into your routine – a habit. 'Habit is from our brain's link a particular behaviour (running) to specific cues or contexts [My kit's on the radiator; it's Saturday morning – parkrun time], says Dr Amanda Rebar, director of the Motivation of Health Behaviours Lab at Central Queensland University, Australia. 'Initially, a reward is gained from the behaviour [I'll see my running buddies; I'll feel good afterwards]. But eventually, as the association between the behaviour and the cue strengthens, you'll engage in the behaviour even without the prospect of the reward.'

One study found that for exercise to become a habit, subjects needed to do it four times a week for a minimum of six weeks, but Rebar says habit-forming is highly individual. 'Importantly, forming a habit will not necessarily make the running itself easier,' she says. 'What the habit does is make deciding to do your run your default position.' Rather than looking out the window at the rain and debating, you simply grab your waterproof jacket and go.

DEVOTION TO MOTION

ONCE RUNNING BECOMES an established and valued part of our lives, we can get little surges of 'anticipatory' chemical joy even before we work up a sweat – say, when we lace up our shoes or step onto the track. And conversely, we get a bit grumpy when we can't get out and run. OK, 'very grumpy,' McGonigal cites a study in which the brain circuitry of committed exercisers viewing images of other people exercising responded in the same way as the brain circuitry of smokers who were shown cigarettes. Does that mean we've become addicts, chasing that runner's high like a drug addict pursuing their next fix?

'Like highly addictive substances, regular exposure to exercise will trigger changes in the reward system that teach the brain to like it, want it and need it,' says McGonigal. But there are two key differences. With substance abuse, the brain becomes so primed to its drug of choice that other potentially rewarding stimuli (eg food, love) lose all appeal. And, secondly, the extent to which drugs and alcohol stimulate the reward system is so large that the brain attempts to restore normality by suppressing it.

Happily, exercise has the opposite effect. 'The reward system's response to exercise is slower and more measured, so these adverse reactions don't take place,' says McGonigal. Rather than reducing the circulation of dopamine and making dopamine receptors less available, physical activity enhances both. 'Instead of annihilating your capacity for pleasure, exercise expands it.'

This could be why running – and exercise in general – can be such a useful tool in helping people recover from substance addiction. Research has shown that exercise early in the abstinence period helps quitters stay on course, and that it can help normalise dopamine signalling.

Running coach Mike Ferrullo started getting high when he was just 15. After years spent in and out of rehab – and even a spell in prison – he stumbled upon running and immediately found some solace and benefit. 'When I am running,

it helps me be in the moment,' he says. 'Running gives me a sense of childlike freedom. It especially helps me when I am stressed out and feeling overwhelmed with things.'

Running played a big role in Ferrullo's recovery. 'It helped me experience success, find my identity and realise my potential.' Once sober, he volunteered at a rehab facility, introducing recovering addicts to running. 'When you do something and it saves your life, you want to pass it on,' he says.

While many attendees found it enormously helpful, Ferrullo realised that once they left the facility, they also lost the support and sense of community they'd come to rely on. So, in 2016, he set up the Boston Bulldogs, a US running club for those in recovery and their families.

That was five years ago and there are now over 300 members. 'The onus is on fun, enjoyment, community and mutual support. Addicts have to start to enjoy their lives, not just stay away from drugs,' he says. 'Running helps them feel good about themselves. It gives them hope that they can reconnect with the world.'

The community aspect – both at the Bulldogs and in running generally – is significant. One of the other stimulants of the pleasure-boosting endocannabinoid system is social connection: cooperation, bonding and sharing – all of which would have helped ancient societies survive and thrive.

We might lightheartedly refer to our running 'addiction', but to McGonigal, it's more akin to love or devotion. Yes, we feel unhappy if we're 'parted' from it, as when we can't be with a loved one. But that's a tiny minority of cases, we don't need more and more of it to feel happy, and we don't sacrifice our overall wellbeing in its pursuit. 'I think we need to be sparing in our use of the term "addiction",' says Lieberman. 'We clearly evolved to have reward systems for things that benefit us and being active is one of them. A need, or desire, to reward myself with physical activity is not abnormal.'

All aerobic exercise – swimming, hiking, biking, dancing etc – can trigger the cascade of reward chemicals in the brain, but many experts believe there's something special about running. 'Running is such a clear metaphor for whatever you're going through in life,' says McGonigal. 'Finding your path. Moving forward. Overcoming challenges. That's why the people who most need the joy of movement, such as those who've overcome challenges and addictions, so often find it in running.'

Daniel Lieberman is far more literal. 'We didn't evolve to cycle or to row. We evolved to walk, run, carry things. It's part of who we are.' 

Hope for the joyless runner

Expert advice for those yet to see running as their happy place

Plug in / 'Listening to music is a great way to give you a dopamine adrenaline and endorphin hit,' says McGonigal.	Be gentle / 'Meet your body where it is,' says McGonigal. 'Exercise shouldn't feel punishing.'	Mix it up / 'Variety is enjoyable, so experiment a little,' says Lieberman.	Keep the faith / 'Accept you may need to endure some joyless runs before you reshape your brain chemistry.' Don't focus on feeling good during exercise, but after,' says Ratchien. 'If you stick with it, you'll start to feel the benefits to mood.'	End on a high / 'Research shows that, owing to a phenomenon known as "forecast myopia", we remember the last part of an experience. Finishing strong, not sloggling up a hill, increases the chances you'll view running positively.'
Get outdoors / 'Studies show green exercise' has a positive impact on mood and stress relief.	Buddy up / 'Moving with others boosts endocannabinoids and endorphins,' says McGonigal.	Make it a habit / 'The hardest part of running is the decision to put on your shoes,' says Rebar. Build it into your routine.		



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