The science of love
I get a kick out of you
Feb 12th 2004
From The Economist print edition

Scientists are finding that, after all, love really is down to a chemical addiction between people

OVER the course of history it has been artists, poets and playwrights who have made the greatest progress in humanity's understanding of love. Romance has seemed as inexplicable as the beauty of a rainbow. But these days scientists are challenging that notion, and they have rather a lot to say about how and why people love each other.

Is this useful? The scientists think so. For a start, understanding the neurochemical pathways that regulate social attachments may help to deal with defects in people's ability to form relationships. All relationships, whether they are those of parents with their children, spouses with their partners, or workers with their colleagues, rely on an ability to create and maintain social ties. Defects can be disabling, and become apparent as disorders such as autism and schizophrenia—and, indeed, as the serious depression that can result from rejection in love. Research is also shedding light on some of the more extreme forms of sexual behaviour. And, controversially, some utopian fringe groups see such work as the doorway to a future where love is guaranteed because it will be provided chemically, or even genetically engineered from conception.

The scientific tale of love begins innocently enough, with voles. The prairie vole is a sociable creature, one of the only 3% of mammal species that appear to form monogamous relationships. Mating between prairie voles is a tremendous 24-hour effort. After this, they bond for life. They prefer to spend time with each other, groom each other for hours on end and nest together. They avoid meeting other potential mates. The male becomes an aggressive guard of the female. And when their pups are born, they become affectionate and attentive parents. However, another vole, a close relative called the montane vole, has no interest in partnership beyond one-night-stand sex. What is intriguing is that these vast differences in behaviour are the result of a mere handful of genes. The two vole species are more than 99% alike, genetically.
Why do voles fall in love?

The details of what is going on—the vole story, as it were—is a fascinating one. When prairie voles have sex, two hormones called oxytocin and vasopressin are released. If the release of these hormones is blocked, prairie-voles' sex becomes a fleeting affair, like that normally enjoyed by their rakish montane cousins. Conversely, if prairie voles are given an injection of the hormones, but prevented from having sex, they will still form a preference for their chosen partner. In other words, researchers can make prairie voles fall in love—or whatever the vole equivalent of this is—with an injection.

A clue to what is happening—and how these results might bear on the human condition—was found when this magic juice was given to the montane vole: it made no

difference. It turns out that the faithful prairie vole has receptors for oxytocin and vasopressin in brain regions associated with reward and reinforcement, whereas the montane vole does not. The question is, do humans (another species in the 3% of allegedly monogamous mammals) have brains similar to prairie voles?

To answer that question you need to dig a little deeper. As Larry Young, a researcher into social attachment at Emory University, in Atlanta, Georgia, explains, the brain has a reward system designed to make voles (and people and other animals) do what they ought to. Without it, they might forget to eat, drink and have sex—with disastrous results. That animals continue to do these things is because they make them feel good. And they feel good because of the release of a chemical called dopamine into the brain. Sure enough, when a female prairie vole mates, there is a 50% increase in the level of dopamine in the reward centre of her brain.

Similarly, when a male rat has sex it feels good to him because of the dopamine. He learns that sex is enjoyable, and seeks out more of it based on how it happened the first time. But, in contrast to the prairie vole, at no time do rats learn to associate sex with a particular female. Rats are not monogamous.

This is where the vasopressin and oxytocin come in. They are involved in parts of the brain that help to pick out the salient features used to identify individuals. If the gene for oxytocin is knocked out of a mouse before birth, that mouse will become a social amnesiac and have no memory of the other mice it meets. The same is true if the vasopressin gene is knocked out.

The salient feature in this case is odour. Rats, mice and voles recognise each other by smell. Christie Fowler and her colleagues at Florida State University have found that exposure to the opposite sex generates new nerve cells in the brains of prairie voles—in particular in areas important to olfactory memory. Could it be that prairie voles form an olfactory “image” of their partners—the rodent equivalent of remembering a personality—and this becomes linked with pleasure?

Dr Young and his colleagues suggest this idea in an article published last month in the Journal of Comparative Neurology. They argue that prairie voles become addicted to each other through a process of sexual imprinting mediated by odour. Furthermore, they suggest that the reward mechanism involved in this addiction has probably evolved in a similar way in other monogamous animals, humans included, to regulate pair-bonding in them as well.
You might as well face it...

Sex stimulates the release of vasopressin and oxytocin in people, as well as voles, though the role of these hormones in the human brain is not yet well understood. But while it is unlikely that people have a mental, smell-based map of their partners in the way that voles do, there are strong hints that the hormone pair have something to reveal about the nature of human love: among those of Man's fellow primates that have been studied,

monogamous marmosets have higher levels of vasopressin bound in the reward centres of their brains than do non-monogamous rhesus macaques.

Other approaches are also shedding light on the question. In 2000, Andreas Bartels and Semir Zeki of University College, London, located the areas of the brain activated by romantic love. They took students who said they were madly in love, put them into a brain scanner, and looked at their patterns of brain activity.

The results were surprising. For a start, a relatively small area of the human brain is active in love, compared with that involved in, say, ordinary friendship. “It is fascinating to reflect”, the pair conclude, “that the face that launched a thousand ships should have done so through such a limited expanse of cortex.” The second surprise was that the brain areas active in love are different from the areas activated in other emotional states, such as fear and anger. Parts of the brain that are love-bitten include the one responsible for gut feelings, and the ones which generate the euphoria induced by drugs such as cocaine. So the brains of people deeply in love do not look like those of people experiencing strong emotions, but instead like those of people snorting coke. Love, in other words, uses the neural mechanisms that are activated during the process of addiction. “We are literally addicted to love,” Dr Young observes. Like the prairie voles.

It seems possible, then, that animals which form strong social bonds do so because of the location of their receptors for vasopressin and oxytocin. Evolution acts on the distribution of these receptors to generate social or non-social versions of a vole. The more receptors located in regions associated with reward, the more rewarding social interactions become. Social groups, and society itself, rely ultimately on these receptors. But for evolution to be able to act, there must be individual variation between mice, and between men. And this has interesting implications.

Last year, Steven Phelps, who works at Emory with Dr Young, found great diversity in the distribution of vasopressin receptors between individual prairie voles. He suggests that this variation contributes to individual differences in social behaviour—in other words, some voles will be more faithful than others. Meanwhile, Dr Young says that he and his colleagues have found a lot of variation in the vasopressin-receptor gene in humans. “We may be able to do things like look at their gene sequence, look at their promoter sequence, to genotype people and correlate that with their fidelity,” he muses.

It has already proved possible to tinker with this genetic inheritance, with startling results. Scientists can increase the expression of the relevant receptors in prairie voles, and thus strengthen the animals' ability to attach to partners. And in 1999, Dr Young led a team that took the prairie-vole receptor gene and inserted it into an ordinary (and therefore promiscuous) mouse. The transgenic mouse thus created was much more sociable to its mate.

Love, love me do

Scanning the brains of people in love is also helping to refine science's grasp of love's various forms. Helen Fisher, a researcher at Rutgers University, and the author of a new

book on love*, suggests it comes in three flavours: lust, romantic love and long-term attachment. There is some overlap but, in essence, these are separate phenomena, with their own emotional and motivational systems, and accompanying chemicals. These systems have evolved to enable, respectively, mating, pair-bonding and parenting.

Lust, of course, involves a craving for sex. Jim Pfaus, a psychologist at Concordia University, in Montreal, says the aftermath of lustful sex is similar to the state induced by taking opiates. A heady mix of chemical changes occurs, including increases in the levels of serotonin, oxytocin, vasopressin and endogenous opioids (the body's natural equivalent of heroin). “This may serve many functions, to relax the body, induce pleasure and satiety, and perhaps induce bonding to the very features that one has just experienced all this with”, says Dr Pfaus.

Then there is attraction, or the state of being in love (what is sometimes known as romantic or obsessive love). This is a refinement of mere lust that allows people to home in on a particular mate. This state is characterised by feelings of exhilaration, and intrusive, obsessive thoughts about the object of one's affection. Some researchers suggest this mental state might share neurochemical characteristics with the manic phase of manic depression. Dr Fisher's work, however, suggests that the actual behavioural patterns of those in love—such as attempting to evoke reciprocal responses in one's loved one—resemble obsessive compulsive disorder (OCD).

That raises the question of whether it is possible to “treat” this romantic state clinically, as can be done with OCD. The parents of any love-besotted teenager might want to know the answer to that. Dr Fisher suggests it might, indeed, be possible to inhibit feelings of romantic love, but only at its early stages. OCD is characterised by low levels of a chemical called serotonin. Drugs such as Prozac work by keeping serotonin hanging around in the brain for longer than normal, so they might stave off romantic feelings. (This also means that people taking anti-depressants may be jeopardising their ability to fall in love.) But once romantic love begins in earnest, it is one of the strongest drives on Earth. Dr Fisher says it seems to be more powerful than hunger. A little serotonin would be unlikely to stifle it.

Wonderful though it is, romantic love is unstable—not a good basis for child-rearing. But the final stage of love, long-term attachment, allows parents to co-operate in raising children. This state, says Dr Fisher, is characterised by feelings of calm, security, social comfort and emotional union.

Because they are independent, these three systems can work simultaneously—with dangerous results. As Dr Fisher explains, “you can feel deep attachment for a long-term spouse, while you feel romantic love for someone else, while you feel the sex drive in situations unrelated to either partner.” This independence means it is possible to love more than one person at a time, a situation that leads to jealousy, adultery and divorce—though also to the possibilities of promiscuity and polygamy, with the likelihood of extra children, and thus a bigger stake in the genetic future, that those

behaviours bring. As Dr Fisher observes, “We were not built to be happy but to reproduce.”

The stages of love vary somewhat between the sexes. Lust, for example, is aroused more easily in men by visual stimuli than is the case for women. This is probably why visual pornography is more popular with men. And although both men and women express romantic love with the same intensity, and are attracted to partners who are dependable, kind, healthy, smart and educated, there are some notable differences in their choices. Men are more attracted to youth and beauty, while women are more attracted to money, education and position. When an older, ugly man is seen walking down the road arm-in-arm with a young and beautiful woman, most people assume the man is rich or powerful. These foolish things

Of course, love is about more than just genes. Cultural and social factors, and learning, play big roles. Who and how a person has loved in the past are important determinants of his (or her) capacity to fall in love at any given moment in the future. This is because animals—people included—learn from their sexual and social experiences. Arousal comes naturally. But long-term success in mating requires a change from being naive about this state to knowing the precise factors that lead from arousal to the rewards of sex, love and attachment. For some humans, this may involve flowers, chocolate and sweet words. But these things are learnt.

If humans become conditioned by their experiences, this may be the reason why some people tend to date the same “type” of partner over and over again. Researchers think humans develop a “love map” as they grow up—a blueprint that contains the many things that they have learnt are attractive. This inner scorecard is something that people use to rate the suitability of mates. Yet the idea that humans are actually born with a particular type of “soul mate” wired into their desires is wrong. Research on the choices of partner made by identical twins suggests that the development of love maps takes time, and has a strong random component.

Work on rats is leading researchers such as Dr Pfaus to wonder whether the template of features found attractive by an individual is formed during a critical period of sexual-behaviour development. He says that even in animals that are not supposed to pair-bond, such as rats, these features may get fixed with the experience of sexual reward. Rats can be conditioned to prefer particular types of partner—for example by pairing sexual reward with some kind of cue, such as lemon-scented members of the opposite sex. This work may help the understanding of unusual sexual preferences. Human fetishes, for example, develop early, and are almost impossible to change. The fetishist connects objects such as feet, shoes, stuffed toys and even balloons, that have a visual association with childhood sexual experiences, to sexual gratification.

So love, in all its glory, is just, it seems, a chemical state with genetic roots and environmental influences. But all this work leads to other questions. If scientists can make a more sociable mouse, might it be possible to create a more sociable human? And what about a more loving one? A few people even think that “paradise-engineering”,

dedicated to abolishing the “biological substrates of human suffering”, is rather a good idea.
As time goes by

Progress in predicting the outcome of relationships, and information about the genetic roots of fidelity, might also make proposing marriage more like a job application—with associated medical, genetic and psychological checks. If it were reliable enough, would insurers cover you for divorce? And as brain scanners become cheaper and more widely available, they might go from being research tools to something that anyone could use to find out how well they were loved. Will the future bring answers to questions such as: Does your partner really love you? Is your husband lusting after the au pair?

And then there are drugs. Despite Dr Fisher's reservations, might they also help people to fall in love, or perhaps fix broken relationships? Probably not. Dr Pfaus says that drugs may enhance portions of the “love experience” but fall short of doing the whole job because of their specificity. And if a couple fall out of love, drugs are unlikely to help either. Dr Fisher does not believe that the brain could overlook distaste for someone—even if a couple in trouble could inject themselves with huge amounts of dopamine.

However, she does think that administering serotonin can help someone get over a bad love affair faster. She also suggests it is possible to trick the brain into feeling romantic love in a long-term relationship by doing novel things with your partner. Any arousing activity drives up the level of dopamine and can therefore trigger feelings of romance as a side effect. This is why holidays can rekindle passion. Romantics, of course, have always known that love is a special sort of chemistry. Scientists are now beginning to show how true this is.

* “Why We Love: The Nature and Chemistry of Romantic Love”, by Helen Fisher. Henry Holt and Company, New York.