A teenage brain is a work of art in progress. After a spurt in growth before puberty, children end up with more grey matter - the nerve cells that let us think - than they will ever have again. Adolescence is, then, a time of rapid pruning back, a discarding of unwanted neural connections which sees grey matter lost in a wave from the back of the brain to the front.

A University of Melbourne neuroscientist, Professor Stephen Wood, likens this refining of our most important organ to a sculpture being created, as unwanted bits are chipped away. "You end up with less stone or clay, but it is a better finished work," he says.

Recent brain-imaging studies show the honing process is not complete until young people have reached their early to mid-20s. The front parts of the brain that control judgment and caution are the last to mature, which helps explain why teenagers have a reputation for being impulsive, emotionally volatile and reckless.

Meanwhile, young people's surging hormones are driving a desire to seek out new thrills and experiences, especially for boys.

"There is a developmental mismatch, with increased drive and no brakes," Professor Wood says.

Some researchers are critical that findings about the teenage brain can be used to reinforce negative stereotypes of adolescents and threaten their human rights, but the brain scans also provide insights into the special vulnerability of young people to addictive substances and mental illness.

They reinforce, too, that the teen years are not just a time of risk, but one of opportunity, creativity and learning. And with the brain still plastic, it is a period when the right kind of intervention - in particular, firm but warm care from adults with high expectations of a teenager - can have a transforming effect on them.

Early childhood can be thought of as like walking through a deep ravine, as far as the brain is concerned, Professor Wood says. To stop a child learning to talk, for example, parents would have to go to extraordinary lengths, preventing them from hearing any speech.

But by adolescence, brain development is more like a narrow goat track. Teenagers may wander off course, "But it is not that hard to knock them back into place," he says.

In his new book, Teenagers: A Natural History, Dr David Bainbridge praises the teenage brain as one of the greatest achievements of human evolution. For our brains to become huge - almost three times too big for an animal our size - the unique innovation of a teenage decade of radical change and cerebral reorganisation was needed.

The reason humans live so long is to nurture the extraordinary brains of teenagers, Bainbridge recently told the Guardian. "We shouldn't be criticising teenagers, we should be celebrating them."

Until a few decades ago, it was thought the brain was fully formed by the age of 12 or so. "Wrapped within its tough leathery membrane, surrounded by a protective moat of fluid and completely encased in
bone", it was well safeguarded from the probing of scientists, says an American researcher, Dr Jay Giedd, of the US National Institute of Mental Health.

But the invention of magnetic resonance imaging changed that, and since 1989 his institute has been closely following teenage brain development. About 390 healthy people aged between three and 27 have been scanned, and Dr Giedd outlined the findings last year in a paper in the Journal Of Adolescent Health.

Brain size is very variable, he says, and healthy children at the same age have as much as a 50 per cent difference in total brain volume. By age six, the brain is about 95 per cent of its peak size, which is reached at about 10.5 years in girls and 14.5 years in boys, before the decline in grey matter and pruning of neural connections begins.

On the other hand, electrical insulation is laid down during adolescence, with the amount of white matter increasing. Like switching from dial-up internet to broadband, this speeds up the transmission of signals so the brain eventually becomes a super-fast information highway.

Annual increases in the size of the corpus callosum, a structure of 200 million connections between the left and the right side of the brain, are also greatest during adolescence, the scans show. If you want your child to be a soccer pro, rock star or language whiz, start them practicing early to capitalise on this growth in the inter-connectedness of the brain, says Dr Elizabeth McAnarney of the University of Rochester, in a commentary on Dr Giedd's findings. "A given capability, such as musical or athletic ability, may never be developed if not nurtured during childhood and adolescence."

Wood says a surge of hormones at puberty tends to make teenagers more emotionally reactive, and relationships with peers become very important. The brain's reward centres are also more active during adolescence than in adulthood, driving teenagers to seek out new sensations. "They become more interested in doing risky things, whether it's extreme sports or stupid behaviour like hanging onto the back of a train."

As a species, this has been useful in as much as it spurs young people to move out of the comfort zone of the family and start to explore the wider world. "If everyone is risk-averse and stays close to where they were born, then they quickly run out of food and resources." But the brain can still take many years after puberty to develop the "brakes" that allow young people to think about the consequences of their actions and be more cautious, Professor Wood says.

As part of the drive for new experiences, trying drugs and alcohol can be very tempting, but with the brain still developing this can have serious effects. "The younger people start drinking or using cannabis, the worse it is for their brains."

And the earlier they start, the more likely they are to become addicted, because the substances can affect the way the brain's control mechanisms develop.

The brain is also particularly vulnerable to going awry at this time. "About three-quarters of all mental illnesses have their origins between the ages of 15 and 25," Professor Wood says, adding that the diagnosis may often come later.

His research with colleagues has shown that the brains of young people who develop psychosis appear to be developing faster than normal, with greater loss of grey matter for their age than others who do not develop a mental illness.
It is not yet possible to prevent psychosis, but finding ways to delay the onset could lead to better outcomes because more of the brain will have matured, Professor Wood says.

Dr McAnarney says factors such as self-esteem, being connected to family and school, and having a set of beliefs all help protect the emotional health of adolescents, and can help put a brake on reckless behaviour until the prefrontal cortex of the brain is fully developed.

"Our forefathers were correct in providing structure and guidance for developing adolescents through close family, school and community relationships. What one hopes is that the adolescent will incorporate lessons learned from these institutions into their own repertoire."

However, a Melbourne youth expert, Professor Judith Bessant, is concerned the notion that adolescents are "hard-wired for risk" is being used to reinforce negative stereotypes of teenagers and to undermine their rights, in a similar way to past claims that women and black people had inferior brains.

The evidence linking brain structure and behaviour is not strong, says Professor Bessant, of RMIT University. "It is a biological determinist argument that is pretty simplistic." Yet it is leading to a push to increase the age at which young people can drive, drink or carry out other activities, reducing the opportunities for them to learn through experience and develop intuition and insight through taking on responsibilities.

Professor Wood, on the other hand, believes it is appropriate to use the new findings to, for example, limit the number of passengers a P-plate driver can carry. "There is plenty of evidence that mature judgment takes time to develop. To me, that is evidence-based policymaking." But he does caution against falling for the stereotype that all teenagers are rebellious risk-takers. "A lot of adults forget what it was like to be an adolescent."

Adolescence is a time of dramatic brain changes, Dr Giedd says. "But the teen brain is not a broken or defective adult brain."

Adolescence is one of life's great periods, Professor Bainbridge says. "We've become blind to the fact that our teenage years are the most dramatic, intense and exciting of our lives. Everything is very vivid."