THE IMPACT OF ALCOHOL ON THE ADOLESCENT BRAIN

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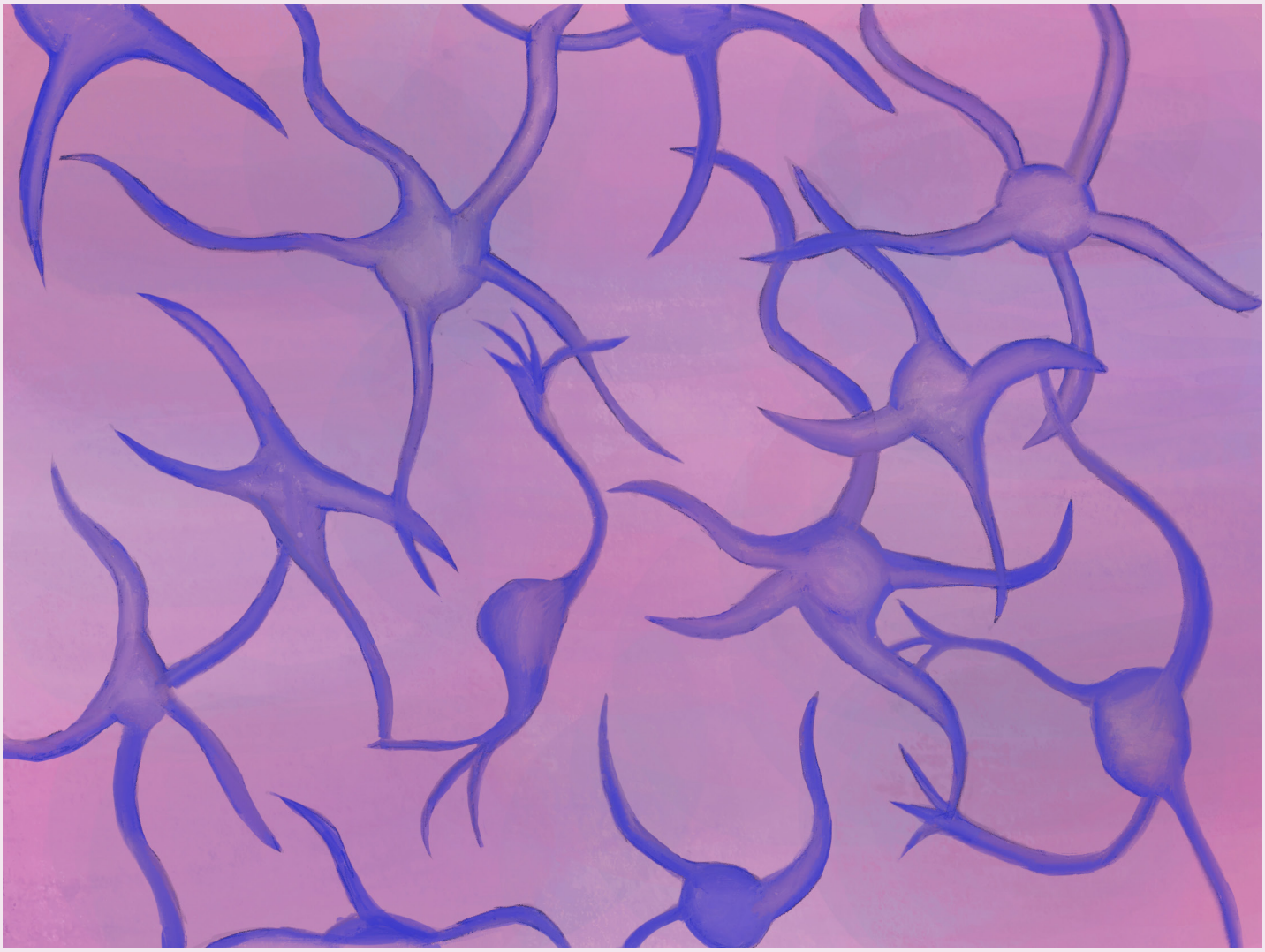
Everyone knows that the legal drinking age in America is 21, but everyone also knows that anything is legal until you get caught. Across the world, teenagers and young adults consider alcohol an enjoyable weekend stress-reliever, but the long-term impacts of this temporary bliss remain largely undiscussed among younger populations. The neurological damage seen in adolescents that consume excessive amounts of alcohol can cause long-term impairment to a developing brain. Adolescent brain development is a dynamic process of neurological and cognitive changes. Such changes can lead to increased impulsivity contributing to poor decision-making, such as alcohol (over)consumption. Alcohol consumption, in turn, has various effects on the brain including a reduction in brain volume of white and grey matter, neurotransmitter signaling, and memory impairment, all of which can directly affect a teen's success in both the short and long term.

> *"ALCOHOL IMPAIRS MEMORY FORMATION, ESPECIALLY IN YOUNG ADULTS, DAMAGING THE CRUCIAL HIPPOCAMPUS, VITAL FOR LEARNING AND SPATIAL NAVIGATION"*

Adolescents usually feel less sensitive to certain effects of alcohol. This physical tolerance conceals possibilities of long-term damage [4]. In adults, the frontal lobe is fully developed allowing the brain to recognize patterns of alcohol consumption as dangerous. This allows the brain to send physical signals like loss of motor function and drowsiness to the body to act as a sign to stop drinking [4]. Since adolescents do not have a fully developed frontal cortex, they are much less likely to experience outward symptoms that act as a signal to stop. Thus, adolescents are much more likely to binge drink due to their lack of sensitivity [4].

This lack of sensitivity is likely due to low GABA levels in adolescent frontal lobes [4]. GABA is the primary inhibitory neurotransmitter in the central nervous system [5]. It slows down the brain nerve cells' ability to send and receive chemical messages to other nerve cells [6]. This means GABA can prevent signals of overconsumption from manifesting as physical symptoms, leading to larger amounts of alcohol consumed. Additionally, lower GABA concentrations in the brain can cause symptoms of anxiety and stress — symptoms that alcohol can combat [7]. Alcohol has the ability to target GABA receptors and create the same chemical effects - like relaxation and euphoria. So, low GABA levels not only have the effect of causing less severe symptoms of alcohol, and lets you drink more and want to do so as a compulsion which can later lead to addiction in adolescents [4]. Detrimental neurological effects of alcohol include impacts on an adolescent's ability to learn and remember things. Specifically, alcohol hinders the ability to form new long-term memories and causes acute memory loss during intoxication. An experimental study conducted on 21-29-year-old adults (that were given alcohol at the time of the study) revealed that while intoxicated participants could recall a list of words given to them in the moment, they struggled to recall the same list 20 minutes later, with younger participants experiencing more difficulty [1]. These findings highlight the detrimental impact of alcohol intoxication on long-term memory formation, particularly in young adults.

Although many brain areas are responsible for memory formation, scientists have identified the hippocampus as the region damaged most by alcohol consumption [1]. The hippocampus is a complex brain structure located deep in the temporal lobe, comprised of distinct subregions, that play an important role in learning, memory, and spatial navigation. Yet despite its importance to brain function, the hippocampus is a structure vulnerable to damage from noxious stimuli, including extreme alcohol



consumption. Memory impairment caused by excessive alcohol intake is akin to that seen in neurological diseases [1].

Individuals with explicit memory impairments often exhibit damage specifically in the hippocampal region known as the CA1 [1]. CA1 is critical to memory processing and consolidation, with studies on rats demonstrating a connection between CA1 neuronal activity and behavior in a given environment [2].. One study observed the CA1 region of rats after they ingested alcohol. The researchers found that activity in CA1 neurons was reduced when small doses of alcohol were administered [1]. When the rats ingested larger amounts of alcohol, activity in the CA1 region stopped almost entirely [1]. These results suggest alcohol has the ability to interfere with brain function and activity in the hippocampus[2].

Notably, the consumption of alcohol has the potential to alter the development of whole brain tissue [2]. The brain comprises two types of tissue: white matter and grey matter. Grey matter mainly consists of neuronal cell bodies and dendrites. Dendrites receive information transmitted by neighboring neurons' axons, usually via neurotransmitters. During the normal maturation process of an adolescent brain, there is a reduction in the volume of grey matter, and an increase in the volume of white matter [3]. The reduction in grey matter does not harm overall growth, instead it strengthens the connections between neurons. The corresponding increase in white matter facilitates more efficient communication and signaling of axons [3]. Alcohol consumption, however, increases the loss of grey matter and impedes increases in white matter volume. This abnormal development manifests itself in long-term cognitive impairment.

Longitudinal studies allow researchers to assess long-term effects of abnormal brain development. In a study conducted by the National Consortium on Alcohol and Neurodevelopment in Adolescence (NCANDA), the authors monitored the alcohol consumption and brain development in a group of adolescents over the course of 5 years [2]. They found adolescents that participated in heavy drinking had greater decreases in gray matter in the brain compared to their non/low-drinking peers. Interestingly, The rapid loss of grey matter was also notable in moderate drinkers.

Rodent and primate studies produced consistent findings with human research. Brain scans conducted on adolescent rhesus macaques showed heavy drinking had a direct relation to reduced rates of brain development over time resulting in cognitive impairments. These findings regarding the macaques' brain development remained consistent with scientists' findings in a follow-up study on the same subjects. [2].

While adults suffer much more severe short-term symptoms, the impact on adolescents is far more insidious as it manifests into long-term detriments to an adolescent's brain development [1]. Through puberty and adolescence, the frontal lobe undergoes significant changes leaving young people vulnerable to impulsivity. binge-drinking and the overconsumption of alcohol can greatly disrupt the trajectory of one's brain development and learning. Teenagers and young adults are more likely to binge drink even though the temporary euphoric effects have long term implications like alterations in brain development and memory impairment. It's easy to bend the rules and not get caught, but just because it's "legal" doesn't mean it's good for you!

If you or someone you love is struggling with alcohol abuse, the SAMHSA's National Helpline, 1-800-662-HELP (4357) has resources and information for individuals and families that are facing mental and/or substance use disorders. alcoholrehabguide.org provides additional resources for counseling and support groups for those struggling with alcoholism.

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