IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, December 2025
Impact Factor: 7.67

Neurobiology of Addictive How Drugs Hijack the Brain

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Abstract: *Individuals, families, communities, and society as a whole bear significant health and financial costs as a result of substance and alcohol use disorders. Not every person responds well to prevention or treatment measures. Usually, the results are modest. The neurobiological alterations that take place when a person moves from recreational substance use to a substance use disorder or addiction have been described in part by advances in neuroscience and addiction research. Behavioral and biological traits that can raise the risk of addiction have been identified through research into the causes and effects of substance use in vulnerable groups, including those whose brains are still developing. These understandings are essential for creating focused prevention and intervention plans. We can improve the efficacy of treatment and support initiatives by customizing strategies to meet the unique requirements of at-risk populations. These f indings are important now because policymakers face challenges with the ongoing opioid crisis, the legalization of marijuana, new drugs entering the market, and high rates of "deaths of despair" from alcohol and drug misuse. Keywords Addiction; substance abuse; neurobiology; alcohol; marijuana; nicotine; opioids, addictive Substances hijack rewards.*

Keywords: neurobiology of addiction, dopamine, serotonin,endorphins , GABA, stimulants, Depressants, opioids, Nicotine, cannabis, hallucinogens, brain rewards pathway, mesolimbic, tolerance, genetic, epigenetic factors

I. INTRODUCTION

"Neurobiology of Addiction" delves into the complex science of substance use disorders and behavioral addictions, presenting addiction as a brain disease that fundamentally alters neural circuits and cognitive functions. It explains how addictive substances hijack the reward pathway, particularly through the neurotransmitter dopamine, resulting in compulsive behavior. The book emphasizes that addiction is the result of complex molecular and cellular changes influenced by both genetic predispositions and environmental factors. The book moves on from basic concepts about brain structures involved in reward and decision-making, such as the prefrontal cortex and nucleus accumbens, to the long-term effects of addiction on brain function. It explores connectivism, neuroplasticity, and genes that affect withdrawal, relapse vulnerability, and onthe-spot tolerance. [18] . A lot of attention is paid to how addiction affects cognitive processes like memory and attention, and how knowledge of these alterations guides the creation of treatment plans. "Neurobiology of Addiction" offers a thorough summary of the neurobiological underpinnings of addiction by combining results from genetic research, neuroimaging, and animal models. [10]. Because of this method, it is a useful tool for researchers, clinicians, and anybody else who wants to learn more about the neuroscience underlying addiction. This is frequently the case and is neither effective in terms of efficacy or treat mentation. Often, veins are modest. Dest. Are frequently modest. The neurobiological alterations that take place when a person moves from recreational substance use to a substance use disorder or addiction have been described in part by advances in neuroscience and addiction research. [.35] The notion of mental illness: is complex and multifaceted, encompassing a range of psychological, emotional, and behavioral issues. Understanding these conditions requires a comprehensive approach that considers the interplay of biological, environmental, and social factors that contribute to mental health challenges. On the boundary between biological facts and social values. American Psychologist, ,.[3] Drug. addiction: Understanding both the and consequences of. These findings are particularly. [34]. While the National Institute on Drug

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Abuse (NI'A) defines addiction as a chronic brain disease, some scholars argue that the neural adaptation's observed in addiction reflect normal learning and plasticity rather than dysfunction [9] Using [35]harmful dysfunction analysis, others suggest that addiction may still qualify as a medical disorder, even if not a classical brain disease. This perspective aligns with evolutionary "hijack" theories, which hold that addictive Substances ,substances cooptancient motivational systems designed for survival rewards [25]deaths of despair" from alcohol and drug substance use and abuse.

1. BRAIN REWARDS PATHWAY.

1.1 Mesocorticolimbic dopamine system dopamine system is critically involved in drug self administration, and also plays important roles in other appetitive behaviours and self stimulation [6] and. [36]This assertion is based on findings using various procedures including dopamine receptor antagonists, 6OHDA lesions, in vivo dopamine concentration measurements in appetitive behavior. Recent studies suggest that the VTA–VS dopamine system is not functionally homogeneous. The medial part of the VTA–VS dopamine system appears to be particularly important for reward and arousal, and that the lateral portion is more closely involved in specific conditioned responses than the medial
(12)

1.2 Ventral tegmental area (VTA)—Careful examination of the VTA
cytoarchitecture reveals that this site consists of heterogeneous elements. [22] Intracranial self administration data suggest that the VTA is functionally heterogeneous and that the posterior VTA, including the central linear nucleus, is more important than the anterior VTA for drug self-administration. Initial behavioral studies suggested that GABA receptor antagonists administered into the anterior, but not posterior, portion of the VTA are rewarding [16] and facilitate locomotion [1]whereas GABA receptor agonists administered into the posterior, but not anterior, portion of the VTA are rewarding [15]and facilitate locomotion)[1] . These findings prompted additional investigations which demonstrated that rats learn to self-administer many drugs into the posterior VTA more vigorously than the anterior. These include cholinergic drugs (carbachol, neostigmine and nicotine) (17). and (36) , opiates (endomorphin-1) (38) cannabinoids (39) cocaine (,27) alcohol-related chemicals (ethanol, acetaldehyde and salsolinol) [29,] serotonin-3 receptor agonists [30]The GABA receptor agonist muscimol is selectively selfadministered into the posterior VTA, but its effective zone appears to be limited in the central linear nucleus of the VTA [15]. summarizes effective sites of nicotine self administration. These drugs are either not self-administered into the anterior VTA or self-administered into the anterior VTA less vigorously than into the posterior VTA. Thus, the initial finding on the rewarding effects of GABA receptor antagonists in the anterior VTA has been reinterpreted in light of further studies on the nearby SUM It should be noted that the drugs listed above may be acting at any number of cell types because the VTA contains various input terminals and other types of neurons besides dopamine neurons, including GABA and glutamate neurons . [37] .

1.3 The prefrontal cortex—Intracranial self-administration studies also found that rats learn to self-administer drugs, including cocaine, into the medial prefrontal cortex, another projection region of the VTA. Although no study has systematically examined its effective zone within the prefrontal cortex, rats learn to self-administer cocaine[7] (and NMDA receptor antagonists–phencyclidine, MK-801, and 3 ((±)2-carboxypiperazin 4yl)propryl1phosphate [36]into the vicinity of the prelimbic area of the medial prefrontal cortex. In addition to the Mesocorticolimbic dopamine system, recent intracranial self-administration studies found other brain regions that are importantly involved in reward. These zones include the SUM, midbrain raphe nuclei, and RMTg, which appear to interact with the VTA–VS dopamine system .

1. Table

Brain Region	Function In Reward Pathway
VTA	Origine Of Dopaminergic Neurons; Initiates Dopamine Release
Nucleus Accumbens	Processes Pleasure and Reinforcement
Prefrontal Cortex	Decision-Making And Regulation Of Reward-Seeking
Amygdala	Emotional Processing Of Rewards

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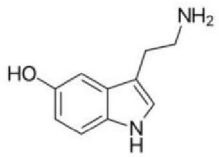
Hippocampus	Memory Of Rewarding Experiences

Ventral Tegmental Area (VTA) Located in the midbrain. Contains dopaminergic neurons (neurons that release dopamine). Sends dopamine signals to other brain areas involved in reward.
Nucleus Accumbens (NAc) Located in the ventral striatum. -The main pleasure centre of the brain. oReceives dopamine from the VTA. o Dopamine release here produces feelings of reward and pleasure.
Prefrontal Cortex (PFC) Involved in decision making, impulse control, and goal-directed behavior. o Interacts with the VTA and NAc to evaluate rewards and plan actions.
Amygdala Processes emotional responses related to rewards (e.g., fear, pleasure).
Hippocampus Responsible for memory formation, linking rewards with experiences and cues.
2.Role Of Neurotransmitters In Addiction-
Neurotransmitters are endogenous chemicals that play a crucial role in transmitting signals across synapses in the brain. These molecules enable neurons to communicate with one another, orchestrating a wide array of physiological and psychological functions . The human brain contains an intricate network of approximately 86 billion neurons, and neurotransmitters serve as the conduits for information transfer within this complex system. They influence everything from mood and cognition to motor control and autonomic functions . Given their central role in brain activity, it is unsurprising that dysregulation of neurotransmitter systems has been implicated in numerous psychological disorders. Neurotransmitters can generally be classified into two categories: excitatory and inhibitory . Excitatory neurotransmitters, such as glutamate, promote the firing of neurons, whereas inhibitory neurotransmitters, like gamma aminobutyric acid (GABA), reduce neuronal activity. Additionally, some neurotransmitters, such as dopamine and serotonin, can have both excitatory and inhibitory effects depending on the receptor subtype they bind to .These chemical messengers are synthesized in neurons, stored in vesicles, and released into the synaptic cleft in response to an action potential. Once released, they bind to specific receptors on the postsynaptic membrane, triggering a cascade of biochemical events that influence neuronal activity .

2.1 Serotonin ; The Mood Regulator Serotonin, chemically known below the
(Fig.no. 1)



stands out as one of the most thoroughly researched neurotransmitters in the realm of mental health and neurobiology. This biogenic amine is synthesized from the essential amino acid tryptophan through a two-step enzymatic process involving tryptophan hydroxylase and aromatic L-amino acid decarboxylase . The chemical structure of serotonin is predominantly located in three major areas of the body:
The gastrointestinal (GI) tract, where it regulates intestinal motility; platelets, where it plays a role in clotting; and the central nervous system (CNS), where it exerts profound effects on a wide array of physiological and psychological functions [28]. Within the CNS, serotonin is critically involved in the regulation of mood, appetite, sleep-wake cycles, cognitive processes, and emotional stability. Its role in mental health is particularly significant, as low levels of serotonin have been strongly linked to major depressive disorder (MDD), a debilitating condition characterized by persistent sadness, loss of interest in activities, and impaired functioning [29]. The monoamine hypothesis of depression, a foundational theory in psychiatry, suggests that deficiencies in monoamine neurotransmitters— especially serotonin—are a key factor underlying depressive symptoms. This hypothesis has been bolstered by the clinical success of selective serotonin reuptake inhibitors (SSRIs), such as fluoxetine (commonly known as Prozac) and sertraline (Zoloft), which are widely prescribed antidepressants. These medications function by inhibiting the reuptake of

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serotonin into presynaptic neurons, thereby increasing its availability in the synaptic cleft and enhancing serotonergic signaling [30]. Beyond its welldocumented role in depression, serotonin dysregulation has been implicated in a variety of anxiety disorders, including generalized anxiety .

2.2 Dopamine: The Reward and Motivation Neurotransmitter Dopamine
(Fig. No.2),
neurotransmitter that has been the focus of extensive
research, plays a pivotal role in various aspects of mental health and brain function. This chemical messenger is synthesized from the amino acid tyrosine and is integral to numerous physiological and psychological processes, including reward processing, motivation, motor control, and executive functions [34]. Its influence extends across several dopaminergic pathways in the brain, such as the mesolimbic and mesocortical pathways, which are essential for regulating emotions, decision-making, and goaldirected behaviour's [33]. Dysregulation of dopamine signaling has been implicated as a core feature in a range of psychological and neurological disorders, highlighting its critical importance in maintaining mental well-being. For instance, in schizophrenia, an overactive dopaminergic system in the mesolimbic pathway is thought to underlie the manifestation of positive symptoms like hallucinations and delusions, which can significantly impair an individual's perception of reality [32]. In contrast, diminished dopaminergic activity in the mesocortical pathway is associated with negative symptoms such as apathy, reduced emotional expression, and social withdrawal. Similarly, dopamine dysregulation plays a significant role in bipolar disorder, where fluctuations in dopamine levels are believed to correspond with the cyclical nature of mood episodes [31]. During manic phases, heightened dopamine activity may contribute to symptoms such as increased energy, impulsive behavior, and euphoria, while depressive episodes are often characterized by reduced dopamine levels, leading to feelings of lethargy, anhedonia, and a lack of motivation [30]. The role of dopamine extends further into conditions like attention-deficit/hyperactivity disorder (ADHD), where 830

2.3 GABA
GABA is the principal inhibitory neurotransmitter in the brain. It tends to reduce neuronal excitability by acting on GABA_A (ion channel) and GABA_B (GPCR) receptors.
In the context of addiction: GABAergic neurons in key brain regions (e.g., in the prefrontal cortex [PFC], ventral pallidum, VTA, NAc) regulate the activity of dopaminergic (DA) neurons either directly or via modulatory interneurons. For example, GABAergic inhibition of VTA dopamine neurons limits DA release into the NAc.
Review findings: In the PFC, GABA system changes are implicated in psychostimulant addiction (e.g., cocaine, amphetamine) via changes in GABA receptor expression/ function, altered interneuron dynamics and thus dysregulated inhibition of cortical outputs.

2.4 Endogenous
The endogenous opioid peptide system includes β-endorphin, enkephalins, dynorphins, nociceptin etc. These bind to μ-opioid (MOR), δ-opioid (DOR), κopioid (KOR) and nociceptin opioid (NOP) receptors.
These opioid peptides are present in key reward/emotion regions: VTA, NAc, hypothalamus (HYP), amygdala (AMY), striatum, hippocampus
They modulate dopamine neurotransmission: For example, activation of MOR on GABAergic interneurons in VTA releases the inhibition on DA neurons → increased DA release in NAc. Thus endogenous opioids can enhance reward signalling by disinhibition of dopamine circuits.

2.5 Functional implications in addiction
Reward and pleasure ("liking"): The opioid system contributes to the pleasurable (hedonic) effects of drugs and other rewards beyond dopamine's "wanting/learning" role. When drugs activate MOR (or other opioid receptors), they can potentiate reward feelings.

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Craving and compulsion: The opioid system can modulate craving and drug seeking behaviours by reinforcing the memory and salience of rewardassociated cues.

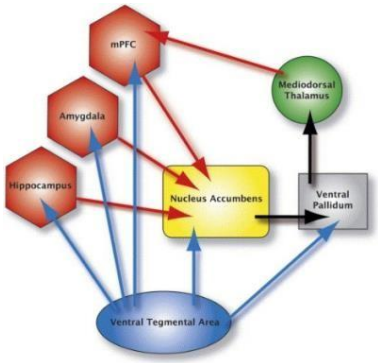
2.6 Glutamate

Drugs of abuse (alcohol, nicotine, cocaine, opioids, etc) impact glutamatergic transmission: release, receptor activation, transporter expression, synaptic plasticity. For example, one review notes:
"All drugs of abuse appear to modulate glutamatergic transmission, albeit by different mechanisms, and this modulation … is believed to result in long-lasting neuroplastic changes in the brain that may contribute to the perseveration of drug seeking behaviour and drug-associated memories

• Key brain regions: The Ventral Tegmental Area (VTA) and the Nucleus Accumbens (NAc) are repeatedly implicated. One review summarises that glutamate transmission in these regions is integral to drug reward.
Synaptic plasticity: Glutamate-dependent LTP/LTD are thought to underlie the association of drug cues, memories of drug use, and craving/relapse vulnerability. • Transporters and homeostasis: The system that clears glutamate (glial glutamate transporters, e.g., EAAT2 / GLT-1) becomes dysregulated in addiction. That may lead to altered extracellular glutamate levels and aberrant signalling.

III. MECHANISM OF DRUG INDUCED BRAIN CHANGES

3.1 Dopamine overflow & initial drug impact



Many addictive drugs acutely lead to enhanced release of dopamine (DA) in the mesocorticolimbic reward circuit (e.g., from the Ventral Tegmental Area (VTA) to the Nucleus Accumbens (NAc)).
For example, repeated psychostimulant exposure elevates extracellular DA levels in the NAc, and also leads to changes like up-regulation of tyrosine hydroxylase (TH) in the VTA, consistent with increased dopaminergic capacity.
The elevated DA triggers stronger activation of DA receptors (especially D1type) on downstream neurons, initiating cascades of intracellular signaling.

3.2 Receptor adaptations: Down-regulation / altered sensitivity

With chronic drug exposure, neurons attempt to maintain homeostasis in the face of persistently elevated DA. One compensatory adaptation is downregulation (or internalisation) of DA receptors (especially D2 and/or D1) and altered receptor coupling.
For example: "Repeated drug exposure … leads to down-regulation of D2 receptors in the ventral tegmental area, together with sensitisation of D1 receptors located to the glutamatergic terminals of the VTA

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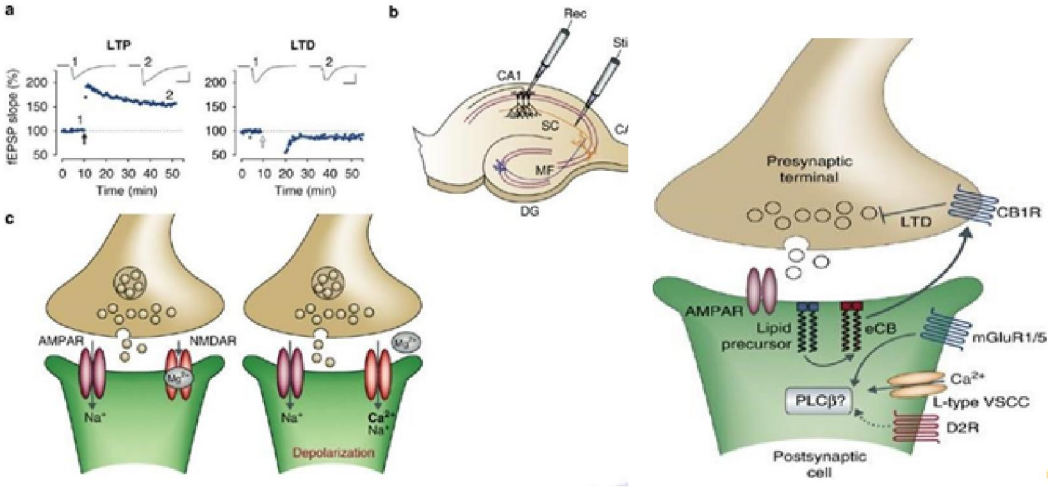
3.3 Synaptic Plasticity & Circuit Remodeling

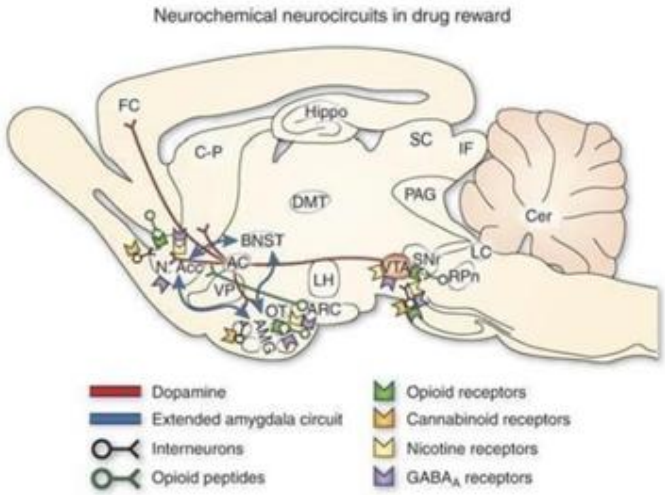


For instance, D1 receptor stimulation enhances phosphorylation of the GluR1 subunit of AMPA receptors via PKA signalling — meaning DA receptors influence AMPA receptor function.
These synaptic adaptations (e.g., long-term potentiation (LTP) or long-term depression (LTD) of synapses) contribute to the persistent changes in neural circuitry that underlie addictive behaviours.

3.4.Transcriptional / Epigenetic Changes: CREB, ΔFosB,

Chronic drug exposure also triggers changes in gene expression via transcription factors such as CREB ΔFosB, and via epigenetic modifications.
Example: A review on ΔFosB states: "Our findings establish chromatin remodelling as an important regulatory mechanism underlying druginduced behavioural plasticity."

3.5.Putting it all together: From acute drug use → long-term circuit change(Fig no. 3)



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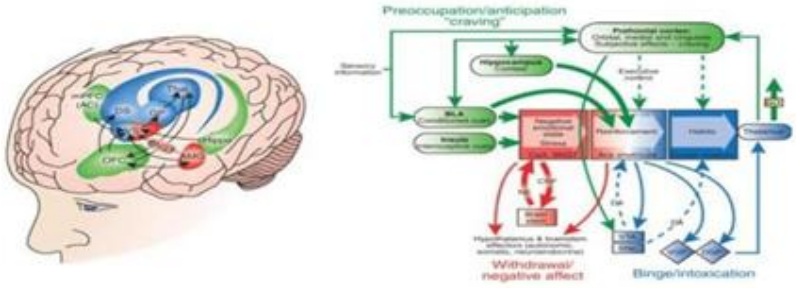

Drug causes massive DA release in the reward pathway → strong activation of DA receptors.
Neurons respond by down-regulating receptors / altering receptorsignaling to maintain equilibrium.
DA receptor changes influence glutamatergic synapses: AMPA/NMDA trafficking, changes in LTP/LTD thresholds → synaptic plasticity (structural and functional).

IV. CLASSES OF ADDICTIVE DRUGS AND THEIR NEURAL EFFECTS

4.1STIMULANTS

Examples: Cocaine, amphetamine, methamphetamine, methylphenidate Neural mechanisms: Stimulants primarily increase synaptic levels of dopamine, norepinephrine, and serotonin, particularly in the mesolimbic dopamine pathway (ventral tegmental area → nucleus accumbens). Cocaine blocks dopamine reuptake transporters (DAT).

4.2. Depressants

Examples: Alcohol, benzodiazepines, barbiturates, gamma-hydroxybutyrate (GHB) Neural mechanisms: Depressants enhance GABAergic transmission through GABA a receptor modulation and inhibit glutamatergic signaling via NMDA receptor antagonism (notably in alcohol).

Neural effects: Overall CNS inhibition, resulting in sedation, anxiolysis, and impaired motor control. Chronic alcohol use alters GABA a receptor subunit composition and upregulates NMDA receptors, promoting tolerance and withdrawal hyperexcitability. Clinical implications: Dependence develops via homeostatic adaptations in inhibitory and excitatory systems, leading to withdrawal seizures, delirium tremens, and cognitive impairment.

4.3. Opioids

Examples: Morphine, heroin, oxycodone, fentanyl Neural mechanisms: Opioids act as agonists at μ-opioid receptors (MORs) located in the ventral tegmental area (VTA), periaqueductal gray, and nucleus accumbens. MOR activation inhibits GABAergic interneurons, disinhibiting dopaminergic neurons and increasing dopamine release in reward circuits.

Neural effects: Produces analgesia, euphoria, and sedation. Chronic exposure leads to receptor desensitization, downregulation of endogenous opioid peptide systems, and severe withdrawal upon cessation. Clinical implications: Opioid addiction reflects strong reinforcement via dopaminergic and nondopaminergic circuits, contributing to high relapse rates.

4.4 Nicotine

Neural mechanisms: Nicotine acts as an agonist at nicotinic acetylcholine receptors (anchors), particularly the α4β2 subtype, located on dopaminergic neurons in the VTA. This activation increases dopamine release in the nucleus accumbens.

Neural effects: Acute use enhances attention, arousal, and reward perception. Chronic exposure induces receptor upregulation and sensitization, contributing to dependence despite tolerance. Clinical implications:

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4.5. Cannabis

Principal psychoactive compound: Δ^9-tetrahydrocannabinol (THC) Neural mechanisms: THC acts as a partial agonist at CB1 cannabinoid receptors, which are Gproteincoupled receptors densely expressed in the hippocampus, basal ganglia, and prefrontal cortex. CB1 activation inhibits presynaptic neurotransmitter release (dopamine, GABA, glutamate).
Neural effects: Produces relaxation, altered perception, and mild euphoria. Chronic exposure alters endocannabinoid signaling and may impair short-term memory and executive function.

4.6. Hallucinogens

Examples: LSD, psilocybin, mescaline, DMT Neural mechanisms: These drugs are agonists or partial agonists at 5-HT_2A receptors in cortical pyramidal neurons, especially in the prefrontal cortex.
Neural effects: Produce profound sensory distortions and altered consciousness via deregulated thalamocortical signaling and increased cortical entropy (neural desynchronization). Clinical implications: Low addiction potential, but can induce persistent perceptual changes or anxiety reactions. Emerging research suggests therapeutic potential in depression and addiction via neuroplasticity modulation.

V. NEURAL CIRCUIT ALTERATION IN CHRONIC ADDICTION

Stress has long been known to increase vulnerability to addiction. The last decade has led to a dramatic increase in understanding the underlying mechanisms for this association. Behavioral and neurobiological correlates are being identified, and some evidence of molecular and cellular changes associated with chronic stress and addiction has been identified. Human studies have benefited from the emergence of sophisticated brain-imaging tools and the cross examination of laboratory-induced methods of stress and craving and their association to specific brain regions associated with reward and addiction risk. This paper focuses primarily on the association between stress and addiction in humans but also draws from the broader animal literature to support the proposed hypotheses. Manuscript NIH-PA Author Manuscript NIH-PA Author Manuscript In the context of strong epidemiological evidence linking early-childhood and adult adversity and risk of addiction, results from basic and human research that point to putative mechanisms underlying this association are presented. A critical role is seen for prefrontal circuits involved in adaptive learning and executive function, including controlling distress and desires/ impulses, in the association between stress and addiction risk. drug use on stress and reward pathways particularly with respect to relapse risk are examined.

VI. TOLERANCE, DEPENDENCE, AND WITHDRAWAL SYSTEM

6.1. Tolerance

Definition: Reduced response to a drug after repeated use, requiring higher doses for the same effect.
Neurochemical basis:
Receptor downregulation/desensitization (e.g., μ-opioid receptors in opioid use). o Neurotransmitter depletion or compensatory changes in dopaminergic, GABAergic, and glutamatergic systems. o Homeostatic adaptation: The brain adjusts to chronic drug presence, shifting baseline neurotransmission.
Example: Chronic alcohol use increases NMDA receptor activity and reduces GABAergic tone

6.2. Dependence

Definition: A physiological state where normal function depends on the presence of the drug.
Mechanism: Chronic drug exposure alters neural circuits, especially in the mesolimbic dopamine pathway (VTA–nucleus accumbens). Neuroadaptations in stress systems (CRF, noradrenaline) and reward circuits promote continued use to avoid negative effects.

6.3.Withdrawal

Definition: Physiological and psychological symptoms appearing when drug use stops.
Neurochemical basis:

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Rebound hyperactivity of systems previously suppressed (e.g., increased NE, glutamate, CRF activity). o Deficient dopamine release → anhedonia, dysphoria. o HPA axis dysregulation → stress, anxiety, autonomic symptoms.
Symptoms: Depend on drug class — e.g., opioids cause sweating, pain, GI upset; stimulants cause depression, fatigue; alcohol causes tremors, seizures

6.4.Physiological changes during use and cessation

Phase	Neurochemical/Physiological State	Key Effects
Drug Use	Increased dopamine, endorphins, or GABA; suppression of stress systems	Euphoria, relaxation, reward
Chronic Use	Receptor adaptation, neurotransmitter imbalance	Tolerance, neurotoxicity
Withdrawal/Cessation	Opposite neurochemical (dopamine ↓, CRF ↑, NE ↑) state	Dysphoria, anxiety, physical symptoms

VII. GENETIC AND EPIGENETIC FACTORS

1. Genetic factors: Certain genes increase vulnerability to addiction by affecting neurotransmitter systems (e.g., dopamine, serotonin) and reward pathways. Variants in genes like DRD2, OPRM1, and COMT can influence how people experience pleasure or stress.
2.Hereditary influence: Addiction tends to run in families — heritability estimates range from 40–60%, meaning genetic background significantly contributes to risk, though environment also matters.
3.Epigenetic factors: Environmental factors such as stress, drug exposure, or trauma can alter DNA methylation, histone modification, and non-coding RNA activity, changing gene expression without altering DNA sequence.
4.Gene expression changes: Repeated drug use can reprogram brain regions like the nucleus accumbens and prefrontal cortex, altering genes linked to reward, learning, and impulse control —these changes can persist long after drug use stops, contributing to relapse.

VIII. NEUROBIOLOGICAL BASE TREATMENT APPROACHES

Neurotransmitter/receptor dysregulation (e.g., serotonin, dopamine, glutamate, GABA). For example in Post-Traumatic Stress Disorder (PTSD) there is altered noradrenergic, serotonergic, glutamatergic and GABAergic signalling. • Circuit dysfunction: e.g., impaired top-down control by prefrontal cortex (PFC) over limbic/emotional/habit systems (amygdala, striatum). For instance in addictions, prefrontal inhibitory control is reduced while limbic reward/habit circuits are up-regulated.
Neuroplasticity / learning & memory processes: Pathology may involve maladaptive learning (e.g., fear conditioning, habit formation) and therapies aim to enhance extinction, reconsolidation, or formation of new adaptive circuits. • Stress / HPA (hypothalamic-pituitary-adrenal) axis / epigenetic modifications: Stress exposure influences brain structure/function, and treatments may aim to correct dysregulated stress systems.

Conclusion

The recent studies reviewed above shows the reward system mediate the efforts of drug self administration is not limited to the Mesocorticolimbic dopamine system. The consistently show that addiction disrupts neurotransmitters balance,with dopamine, glutamate enabling memory driven relapse,GABA and serotonin influencing. Addiction fundamentally alters the brain's reward system through neurotransmitter imbalances, synaptic plasticity, and circuit rewiring, driven by drug classes that exploit dopamine and other pathways. Genetic vulnerabilities and epigenetic changes heighten risk, while chronic use leads to tolerance, dependence, and withdrawal via allostatic shifts. Neurobiology-based treatments, informed by these mechanisms, offer promise for recovery by targeting specific pathways, though integrated approaches combining pharmacology and behavioral interventions are most effective.

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Review articles emphasize addiction as a brain disease, underscoring the need for personalized, evidence-based strategies to restore neural homeostasis. These strategies not only aim to alleviate symptoms but also focus on fostering resilience and promoting long-term recovery. As research continues to evolve, a deeper understanding of individual differences in response to treatment will be crucial in developing more tailored interventions for those affected by addiction.

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IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, December 2025
Impact Factor: 7.67

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