# The Search for a Cure – Zombie Edition

*You have just graduated from medical school with a concentration in neuroscience and the world needs your help! End the Zombie Apocalypse by developing a super drug that can target the specific damaged parts of a zombie brain. In groups, you will use what you have learned about neuroscience and create your very own “cure” using the following synthesized versions of the neurochemicals* ***dopamine, serotonin, GABA, epinephrine, and glutamate.***

**These are the neurotransmitters you have to work with:**

GABA

Glutamate

Serotonin

Epinephrine

Dopamine

Acetylcholine

In **teams of 2**, use the following information on zombie brains and general brain behaviour as well as the information on the different neurotransmitters to determine the perfect combination for your super cure.

## Zombies vs Healthy Humans

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|  | Healthy Humans | Zombies | Brain parts affected |
| Coordination | Normal people can walk around with good coordination between their body and brain. | Zombies stagger around and seem clumsy.  They bump into things, and often hold their arms out for balance. | The cerebellum is involved in the coordination of motor movements and **maintaining balance**.  The basal ganglia works with the frontal lobe and brain stem to coordinate movement and behavior |
| Appetite | Typically after we eat we get full. We have a varied diet, but do not eat humans (usually). | Zombies are always hungry, even after a huge meal. And they like eating humans- which is a problem. | The hypothalamus connects with many other regions of the brain and is **responsible for controlling hunger, thirst, emotions, body temperature regulation, and circadian rhythms**. |
| Anger | Regular people get angry, and there are some situations where they may even feel rage. However people typically feel anger for a short period of time and then return to their normal emotional state. | Zombies are aggressive at all times. They are extremely violent and tend to attack humans in an enraged state. They are dangerous and cannot be reasoned with. | The amygdala is the brain’s primal emotional center. It is implicated in **the experience of negative emotions like fear and rage**. |
| Intelligence | Humans are able to problem solve, communicate with each other through language, and can make complex decisions. This ability makes them unique and has contributed to their success as a species. | Zombies are known for their stupidity.  They often can’t figure out how to open doors and rarely, if ever, plan ahead. They are terrible problem solvers, and seem to lack any ability to communicate except through indistinguishable grunts. | The cerebrum, and specifically the grey matter, is where our **higher order thinking** takes place. |

## Neurotransmitters

A neurotransmitter is a chemical messenger that carries signals between neurons as well as other cells in the body. These chemicals are released from the end of one neuron (axon terminal) and cross the synapse to receptor sites in the next neuron’s dendrites.

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| Neurotransmitter | Description |
| Acetylcholine | Acetylcholine (often abbreviated ACh) is the most common neurotransmitter. It is located in both the central nervous and peripheral nervous system  As a neuromodulator it acts on basic autonomic and muscular functions (heart rate, breathing). The release of acetylcholine will reduce muscle contractions(e.g. reduce heart rate).  In the central nervous system, it is involved in wakefulness, attentiveness, anger, aggression, sexuality, and thirst, among other things. In the central nervous system, ACh has a variety of effects on plasticity, arousal and reward. ACh has an important role in the enhancement of alertness when we wake up, in sustaining attention and in learning and memory.  Damage to the cholinergic (acetylcholine-producing) system in the brain has been shown to be associated with the memory deficits associated with Alzheimer's disease. ACh has also been shown to promote REM sleep. |
| Norepinephrine | Also known as adrenaline  Causes the feeling of being “revved up” or on edge. It is also important for attentiveness, emotions, sleeping, dreaming, and learning.  Activates a “fight or flight” reaction in the autonomic nervous system.  Norepinephrine, also known as Nor-Adrenaline, is widely distributed throughout your brain and body.  It operates as a neuromodulator that boosts the function of many different cell types to optimize your brain's performance.  This is accomplished via two modes of norepinephrine release: burst and tonic firing.  Through burst firing, NE takes part in your ancient and elegant fight-or-flight survival mechanism providing rapid and accurate assessment of danger and opportunity.  Excessive burst firing of NE, logically, especially if no actual life threatening danger exists, can leave you anxious, vigilant, hyperactive, miseable, and annoying to be around.  Conversely, tonic low grade NE firing exerts beneficial effects on sleep, sustainable concentration, stress resilience, inflammation, and many other important biological processes. Too little tonic firing of norepinephrine can leave you flat, apathetic, foggy, unmotivated, fatigued, miserable, and no fun to be around. |
| Dopamine | Generally involved in regulating motor activity, cognition, motivation, reward and nausea. In the basal ganglia, it is involved in the regulation of mood, sensory perception, and attention.  A burst of dopamine promotes pleasure and happiness. Low levels of dopamine have been linked to disorders like ADHD and social anxiety disorder.  Dopamine functions as both an inhibitory and excitatory neurotransmitter depending upon where in the brain and at which particular receptor site it binds to. Adequate dopamine levels are needed to allow us to focus our attention in the moment and attend to matters at hand (remember that attention deficit is at least in part due to low dopamine).  Dopamine is the main player in regulating our reward circuitry and pleasure centers (hence dopamine's role in addictions).  This all important brain chemical is also critical for memory and motor skills.  Problems can ensue if dopamine is too high or too low.  For example, dramatically elevated levels, the so-called "dopamine storm," can be associated with hallucinations, delusions, agitation, mania, and frank psychosis.  Such a state, fortunately rare, is clinically obvious and constitutes a medical emergency. Low dopamine states, on the other hand are quite common and sometimes go years without being identified let alone treated.  [Dopamine](https://www.integrativepsychiatry.net/dopamine.html) is responsible for motivation, interest, and drive. It is associated with positive stress states such as being in love, exercising, listening to music, and sex . When we don't have enough of it we don't feel alive, we have difficulty initiating or completing tasks, poor concentration, no energy, and lack of motivation. Dopamine also is involved in muscle control and function. Low Dopamine levels can drive us to use drugs (self medicate), alcohol, smoke cigarettes, gamble, and/or overeat. Low dopamine states, on the other hand are quite common and sometimes go years without being identified let alone treated. Such states can cause memory, concentration, and attention problems.  Stimulants such as prescription medications for ADD/ADHD, caffeine, and some street drugs temporarily address symptoms of low dopamine by pushing your existing (but dwindling) supply into the space between two neurons (synapse).  This kind of approach can in the short run improve symptoms but if continued for any length of time inhibit natural transmission and actually cause/hasten dopamine depletion. |
| Glutamate | Plays a role in increasing learning and memory. Glutamate is the major excitatory neurotransmitter in the brain. It is required for learning and memory. Low levels can lead to tiredness and poor brain activity. Increased levels of glutamate can cause death to the neurons (nerve cells) in the brain. Dysfunction in glutamate levels are involved in many neurodegenerative diseases such as Alzheimer's disease, Parkinson's, Huntington's, and Tourette's. High levels also contribute to Depression, OCD, and Autism.  Too much is also known to cause seizures  Malfunction of glutamate has also been associated with Alzheimer's disease |
| Serotonin | Affects attention and other complex cognitive functions, such as sleep (dreaming), eating, mood, pain regulation, body temperature regulation.  Release of serotonin decreases appetite.  Serotonin is deemed to be the master neurotransmitter.  Serotonin imbalance is one of the most often cited contributors to depression and other mood disorders.  It is also intimately tied to many biological processes such as sleep, appetite, pain, digestion, and generalized well-being. Serotonin is critical to feelings of self-worth and happiness and helps protect against both depression and anxiety.  Low serotonin levels can lead to difficulty in focusing and concentrating and can lead to depression. Sustained levels of high stress, lack of sleep, poor nutrition, inflammation, genetic mutations, and certain prescription medications can slowly erode your levels of serotonin leading to depression, worry, insomnia, obsessive thoughts, compulsive behaviors, carbohydrate cravings, PMS, and exaggerated response to pain. |
| GABA  (gamma-aminobutyric acid) | GABA is the most important and common inhibitory neurotransmitter  Stops the brain from becoming overexcited; it calms nerve activity in the brain.GABA contributes to motor control, vision, and many other cortical functions. [It also regulates anxiety.](http://thebrain.mcgill.ca/flash/d/d_04/d_04_m/d_04_m_peu/d_04_m_peu.html)  It is often considered to act as "mother nature's Xanax."  Indeed, it is through the GABA system that most sedatives, prescription sleep aids, and tranquilizers work.  It helps the neurons recover after firing and thereby reduces anxiety, worry, and fretfulness.  In addition, GABA regulates norepinephrine, adrenaline, dopamine, and serotonin, it is a significant mood modulator.  When neurotransmitter testing reveals unusually high levels of GABA, it often reflects your body's attempt to compensate for or balance out abnormally elevated excitatory neurotransmitter activity (stress for example).  The extra GABA may "calm" things down but can lead to unwanted effects such as sluggishness, sleepiness, and brain fog.  Too little GABA, on the other hand, can be associated with high anxiety, impulsivity, inability to handle stress, restlessness, and irritability. |