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## From the Instructor

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Jane McClenathan wrote the essay, “Serotonin Keeps You Sad and Sleepy” for her final paper for the WR 150 seminar “Science Writing for the Public” in the Spring 2013 semester. As a class, we explored what writing about science for the public means. We returned frequently to the definition we constructed as a class and the definition each student constructed for himself or herself. This paper was the final assignment for a six-week long research process. Students explored the literature on a topic of interest, chose a research question, made interpretations about the primary literature, and were asked to write a paper in the style of a Scientific American article.

McClenathan started her process with a rough idea of what she wanted to investigate. She did a great deal of research of the literature and reported her findings with ease; however, she made an important transition that many students were not able to achieve: she defined and interpreted the literature from her stance and attempted to make her own contribution to the field. In writing her paper, McClenathan explored the tension between simplification and “dumbing things down” for her audience. Eventually, she was able to strike a balance between presenting complex ideas that require a great deal of background for full understanding and offering the general public something palatable, interesting, and informative.

— Cynthia & Geoffrey Hill

WR 150: Science Writing for the Public

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## From the Writer

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When faced with the challenge of creating an original *Scientific American* article, I responded with the essay “Serotonin Keeps You Sad and Sleepy.” The prompt—which served as the cumulative assignment for my WR 150 course “Science Writing for the Public”—initially provoked me to write a research paper on stem cell cancer treatments, a topic on which I am fairly versed. But after a few hours of skimming through the abundance of peer-reviewed journal articles of that nature, I realized that the writing process for this assignment would only hold my interest with a narrower scope and a fresh topic. With that in mind and final exams looming, I started anew by researching the proposed causes of depression, eventually stumbling upon serotonin and its concurrent relationship with sleep disorders.

Like an actor getting into character, I found that using the format of a genuine *Scientific American* article motivated me to research well and write efficiently. Though not a typical assignment for a writing course, this exercise exposed me to the type of writing I’m more likely to complete in my career. Once I had finished the tedious process of filtering through the statistical analysis and scientific jargon of various journal articles, I went to the magazine’s website and used its layout to draft my first attempt at the essay, copying fonts and photo placement from the very beginning. With the paper due date as a print deadline and some wiggle room for creativity, I was able to fight my usual procrastination with genuine excitement to complete my work. With various stylistic adjustments, the product came to look, sound, and smell like scientific writing for public consumption.

— Jane McClenathan

## SEROTONIN KEEPS YOU SAD AND SLEEPY

NEUROTRANSMITTER MANIPULATION SHOWS THAT AN  
IMBALANCE IN SEROTONIN MAY CAUSE SIMULTANEOUS  
DEPRESSION AND SLEEP DISORDER SYMPTOMS.

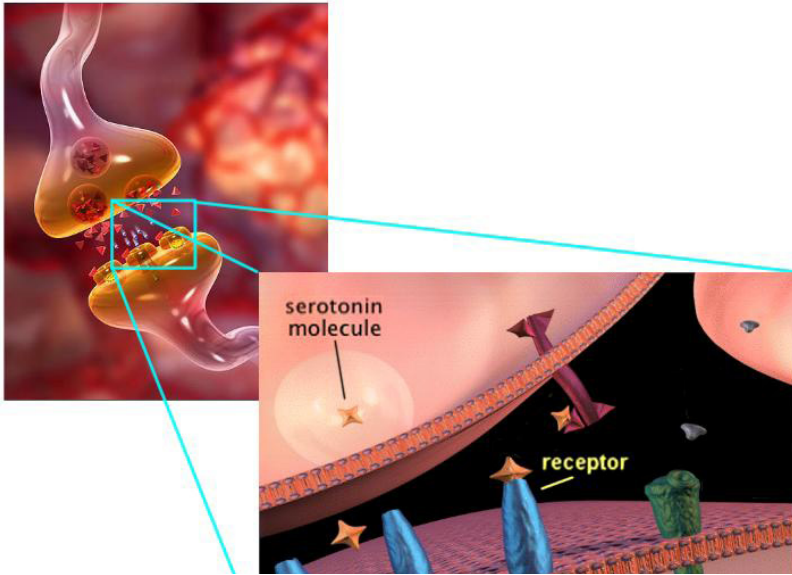
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“I love sleep. My life has the tendency to fall apart when I’m awake, you know?” Ernest Hemingway had a not uncommon (though dreary) outlook on life.<sup>1</sup> As a patient diagnosed with clinical depression, he enjoyed the escape that sleep could bring. Unfortunately, unlike the famous author, many people with this condition find no more relief at night than they do during the day. In fact, a significant portion of depressed patients report sleep disorders as a secondary symptom, yet the existence of a biological link between the two problems remains uncertain.

However, hope exists for the suffering. One brain chemical commonly glorified in scientific literature, serotonin, plays a key role in both emotional stability and sleep patterns. While scientists debate the extent of serotonin’s involvement in the development of depression, most agree that the neurotransmitter clearly plays *some* role in the psychological disorder, albeit one more complex than initially presumed. And depression isn’t the only disorder linked to serotonin—recent studies have identified a relationship between serotonin and sleep disorders like insomnia and sleep apnea. So what does this neurotransmitter do? And why are these links important?

Serotonin, like every other neurotransmitter, is a molecule used to communicate in the brain. When released by a neuron, it travels to the next brain cell, which can either absorb it or block the molecule from entering. If allowed entry, serotonin will prompt its own release by the new cell, triggering a pathway throughout the brain that will eventually lead to the regulation of emotions and circadian rhythms. If blocked, the serotonin

pathway (and in turn any change effected by it) will not occur. With this basic understanding of serotonin in mind, let us move on to discuss the neurotransmitter's role in sleep and depression.



Figures 1 & 2. The meeting of two neurons, called a synapse, where serotonin is sent out of one neuron and absorbed by another through specific receptors.

## What We Know

As previously discussed, the movement of serotonin across neurons creates a *pathway*, which in turn regulates a behavior. However, serotonin is not confined to one route and one set of neurons—various areas in the brain utilize the neurotransmitter to send different messages through the nervous system. In 2000, the *American Journal of Medical Genetics* published an article that related a specific gene to suicidal tendencies, demonstrating the result of *one* failed pathway. This gene codes for a serotonin receptor (5-HT<sub>2A</sub>), a molecule that rests on the edge of a neuron waiting to send serotonin into the cell. With a faulty receptor, the cell cannot accept serotonin, which blocks the normal pathway and prevents any regulation of behavior. The serotonin receptor discussed in this research does *not* allow passage of serotonin into the neuron as it should, and individuals whose bodies produce this receptor tend to have depression with suicidal ideations (Du, et al.). This research did not find a direct relation-

ship between a decrease in serotonin and a problematic symptom; after all, at least seven types of serotonin receptors exist, so the failure of one does not lead to a complete loss of serotonin circulation in the brain (Frazer 1999). However, the breakdown of a receptor *can* lead to the breakdown of a pathway, and the “significant association” between the serotonin receptor gene and suicidal tendencies suggests that the serotonin pathway allowed by this receptor affects emotional stability and happiness (Du, et al. 2000). Without the pathway, serotonin can still travel throughout the brain, but it does not act on the same regions that it would reach via the 5-HT<sub>2A</sub> receptor, and therefore the same behaviors will not necessarily occur. Though it may not have an impressive name, this one receptor (and the serotonin it receives) has quite an important role in securing our mental balance.

Like many neurotransmitters, serotonin has more than one message to convey to its targets in the brain. Twelve years after the completion of the previous study, researchers continued to examine the effects of altered serotonin on behavior, using technology and methods that were unavailable during Du’s experiment. In the June 2012 publication of the *European Journal of Neuroscience*, a study involving the brain chemistry of mice found that serotonin depletion disrupted the circadian rhythm of sleep-wake cycles without actually decreasing the cumulative amount of sleep in mice. Rather than exhibiting insomnia symptoms, mice with abnormally low serotonin levels woke twice as frequently as control mice while sleeping for the same overall amount of time (Nakamaru-Ogiso, et al.). This finding, which opposes previous understandings of the relationship between serotonin and sleep, clarifies one of the key concerns about serotonin and sleep patterns. In previous scientific literature, some studies suggested that a decrease in serotonin led to insomnia, while others argued that serotonin depletion led to lethargy. This new result explains how both conclusions, though incorrect by themselves, can and do occur outside of the laboratory setting: by disrupting the circadian rhythm of sleep-wake cycles, an imbalance in serotonin leads to restless sleep during which the subject wakes often, leading them to lack sleep at night and desire sleep during the day.<sup>2</sup> While the mice studied in the aforementioned experiment share many biological and physiological characteristics with humans, including brain chemistry, they do *not* share their ability to nap throughout

the day with us. So while mice use daylight hours to make up for their wakeful nights, humans with similar serotonin problems have to fend off yawns with coffee and candy bars.

## Connecting the Dots

We know that an imbalance in serotonin can upset circadian rhythms, and we know that improper circulation of serotonin can lead to suicidal thoughts . . . but beyond the scope of scientific inquiry, what significance do these discoveries have on medical advancements? To answer this question, let us revisit the dilemma introduced at the beginning of this article. According to articles from *Biological Psychology*, *Journal of Psychosomatic Research*, *SLEEP*, and *Psychosomatic Medicine*, sleep problems and depression seem to occur together more often than not. Sleep disturbances “belong to the core symptoms of the disorder,” so it follows that one biological cause might exist for both symptoms (Riemann, 2011). While scientific literature floods with research presenting correlations between sleep and depression, sleep and serotonin, and depression and serotonin, one has to ask: could irregular serotonin regulation trigger both depression and sleep disorders?

First, let’s take a step back and consider the “common sense” approaches to why depression and disturbed sleep exist together with such frequency. Some believe that those who lack restful sleep cannot perform to their greatest potential during the day, and therefore find themselves stressed and anxious, eventually leading to depression. Others see the flip-side of that scenario, i.e. those with depression have problems falling and staying asleep due to stressful thoughts and nightmares. While both situations make sense at some level, they ignore the biological facts that we now know play a significant, if not primary role in the development of psychiatric disorders. In a twin study, scientists concluded that 58% of coexisting depression and sleep disorders developed due to gene expression, and while studies vary on exact values, the general trend demonstrates a relationship between genetics, depression, and sleep problems (Gregory, et al. 2011). If biology so clearly points to a genetic basis of these symptoms, certainly some biological product must cause them, which brings our discussion back to serotonin. Considering all three relationships—that between sleep and serotonin, that between depression and serotonin, and that between

sleep and depression—we can begin to draw inferences that will lead us to medically pertinent conclusions.

### Why A Twin Study?

Twin studies are a useful tool in genetic research. Because of their close or identical genetic material, both fraternal and identical twins provide researchers with a way to determine whether the environment or genetic material has caused the exhibition of a trait. A shared trait implies genetic causes, while unshared traits usually signal environmental factors.

### Why It Matters

We know that depleted serotonin can lead to a disruption of circadian rhythms. We know that a lack of serotonin absorption by neurons can lead to plans of suicide. Finally, we know that disrupted sleep occurs commonly in depressed patients, and that this association is usually genetically based. Nonetheless, we have yet to identify the root of the problem. Scientific literature does not state that depletion in serotonin *causes* the disruption of circadian cycles, nor does it state that the irregular serotonin receptor causes suicidal thoughts. However, with so many journals recognizing at least one of the correlations between the two symptoms and a serotonin imbalance, it is not unreasonable to presume that serotonin might be at the source of the coexisting conditions.

Scientists have generally accepted serotonin as a regulator in the sleep-wake cycle, but a fierce debate over its relationship with depression still exists. Some researchers, such as Alan Frazer at the University of Texas, don't think serotonin has much role at all in the development of depression. Others, including Joseph Coyle of Harvard Medical School, assert that a relationship between serotonin and depression—though complicated—clearly exists (Spiegel 2012). This debate, while important to the eventual understanding of how our bodies work, does not necessarily help the advancement of treatments for the two disorders. It also narrows

the critical lens to each individual relationship, but as we can see, a broader scope exists which demands consideration. When considering the three relationships previously mentioned, serotonin takes on a much greater role in the body than it has in individual pathways.

We cannot state that an imbalance in serotonin, whether by depletion or misdirection, causes every case of depression or restlessness. But for the cases that include both depression *and* sleep disruption arising from genetic expression, we *can* conclude that an imbalance in serotonin causes the disorders. With this understanding, scientists can work to develop medicines that reach the source of both symptoms, rather than treating them as separate disorders. Though Hemingway's only respite came in permanent sleep, future sufferers could have a healthy alternative to painful days and restless nights. By acknowledging imbalanced serotonin as a major contributor to coexisting depression and sleep disorders, scientists could provide new patients with the relief that Hemingway never experienced.

## TERMS

### **neuron**

A type of cell found in the brain and nervous system.

### **neurotransmitter**

A molecule transferred between neurons as a means of communication in the brain.

### **circadian rhythms**

Physical, mental, and behavioral changes that occur in a cycle over a 24-hour period. These rhythms regulate the sleep-wake cycle, hormone release, and body temperature, among other functions.

### **receptor**

A "gateway" molecule that allows some substances into the cell while preventing the entry of others.



## NOTES

1. Ernest Hemingway eventually succumbed to his depression, committing suicide in 1961. He was not the first to do so in his family—his father, sister, and brother died in the same manner. The coexisting conditions imply that inheritance (and therefore genetics) factored into the development of these depression cases. (Source: *Running From Crazy*. Dir. Barbara Kopple. Perf. Mariel Hemingway. 2013.)

2. To clarify, an imbalance in serotonin does not make daytime sleep more restful than nighttime sleep. The disruption of circadian rhythms causes frequent awakenings during all periods of rest; however, the restlessness at night increases a patient's need for sleep during the day.

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