# GENERAL SCIENCE NOTE

## THE RAINBOW IS ALL IN YOUR HEAD

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If a tree falls in the forest and there is no one there to hear it, does it make any sound? This question can be the basis of humorous arguments, perhaps just for the sake of arguing! But when we bring an understanding of the physiology of the human brain and sense organs into the picture, the question becomes worthy of some serious consideration. In fact, it can yield fascinating insights into the nature of sound, color, taste, beauty, love, and the Creator's inventive genius.

When a tree falls, its branches push the air aside and strike other trees on the way down, finally smacking the ground with earth-shaking force. All these collisions of object against object or object against the air generate trains of wave forms that vibrate through the air. These traveling vibrations of molecules, or sound waves, in the air are controlled by precisely measurable physical laws. The size and nature of the colliding objects and the force with which they collide, control the shape and complexity of the sound waves which move through the air at a constant speed, precisely controlled by physical law. So it appears that sound is entirely controlled by the laws of physics. But that is a premature conclusion, because so far all we have are vibrations of air molecules. How do these vibrations become sound?

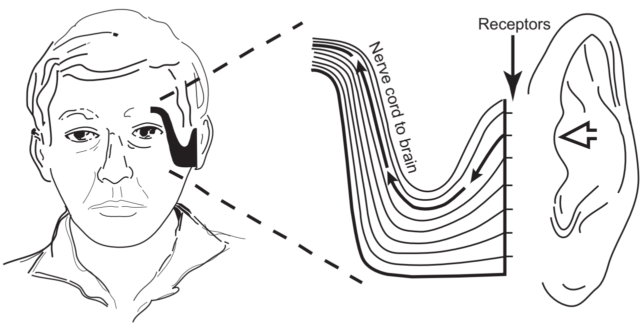
### THE EAR

Now consider the ear of a logger working in the forest. The sound waves, or vibrating air molecules, cause his ear drum to vibrate. This vibration is conveyed to the inner ear, where a long row of receptors respond to the vibrations. The receptors at one end of the row respond to long-wavelength vibrations, creating the perception of low-pitched sound. At the opposite end are receptors activated by short-wavelength vibrations, generating a perception of high-pitched sounds. In between are many other receptors, each tuned to respond to a specific band of intermediate wavelengths, and each ultimately connected to the brain by a nerve. Signals from these receptors are processed along the way as they travel to the brain. There the signals activate a portion of the brain that interprets the signals for us, allowing us to perceive the sound.

What is the nature of the signal that travels along each of the nerves connecting an inner ear receptor to the brain? Is sound carried along the nerve? No, each nerve transmits only an electrical impulse, or signal. If a long-wavelength receptor is stimulated by a long-wavelength vibration, it activates its connecting nerve, and an electrical signal quickly travels to the brain (Figure 1). The electrical signals from a long-wavelength receptor and the signals from a short-wavelength receptor are physiologically the same. These electrical signals change only according to how *loud* the sound is. If the sound becomes louder, signal frequency (signals per second) increases. Figure 1 shows how each inner-ear receptor has its own nerve connection to the brain. The only way the brain can tell if a signal indicates a long or a short-wavelength is by which nerve the signal comes through. So far we still have no sound — only vibrations of air molecules, and movement of electrical impulses along nerves.

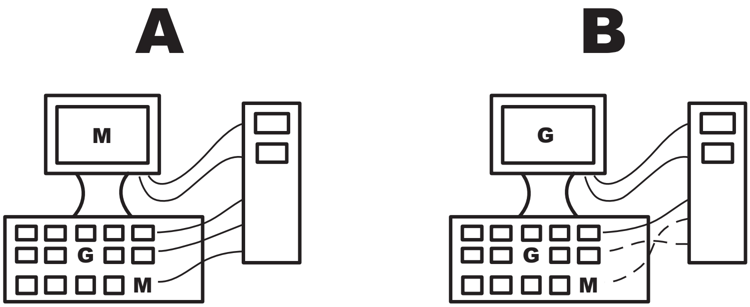
When the brain receives the electrical impulses, we hear sound, and the process is complete. But since the connection between the ear and the brain is only by electrical impulses, the sound of a falling tree has to come from somewhere within the brain. There was no sound traveling along the nerves — only electricity. Somehow the brain receives the incoming pulses of electricity from numerous nerves, and translates them into the conscious perception we call "sound." What we perceive as sound is strictly a sensation generated by the brain, and is not predetermined by the physical laws that govern the vibrations of air molecules.

***FIGURE 1***



To illustrate why sound is not specified by those physical laws, compare the nerve connections from the ear with a computer keyboard. When we press the key with the letter M, a signal is sent to the computer processor, it is manipulated there, and the letter M appears on the monitor (Figure 2A). However, a computer expert can easily change the connections between keyboard and processor, so that pressing the M key results in a G appearing on the monitor (Figure 2B). The result of a key

***FIGURE 2***




press depends upon the electrical connections between keyboard and processor (the computer's brain), and these connections are contingent — based on conscious choices by the programmer, not on specification by any natural law. The letters M or G as they appear on the monitor are made inside the computer. Since we can change the connections and make a G appear from pressing the M key, it is clear the letter that appears is the result of the connections — it depends on which wire goes from the keyboard M into the computer.

In the same way, the sound sensation generated by the brain seems to be controlled by specific nerve connections from the ear. If we could reverse the connections of the long wavelength and short wavelengh receptors (Figure 3), we would hear the long-wavelength vibrations as high-pitched sounds, because the part of the brain that generates the sensation of high-pitched sound was being stimulated as a result of our having changed the wiring.

There is one important difference between the computer and the ear. The fact that the key with M on it is at the bottom middle of the keyboard is also arbitrary, based on a decision of the computer designer. The anatomy of an M key and of a G key is exactly the same, and the

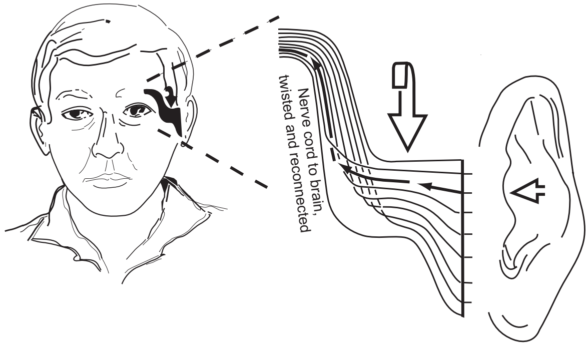



***FIGURE 3. The short-wavelength signal indicated by arrows is now being received by a neuron that is going to a brain center which will interpret it as a low-pitched sound. Likewise, long-wavelength signals will be interpreted as high-pitched sounds.***

determination of which letter comes from which key is decided in the computer processor. However, the receptors in the ear are not all the same. Each one is constructed to respond best to a particular frequency of vibration. Thus the receptors are frequency-specific, but the nerves connecting the receptors to the brain are not frequency specific, and thus our conclusion above remains — unplugging the "cord" from the ear and reversing the connections would reverse the nature of the sounds we hear. A piccolo would sound like a tuba and the tuba would be perceived as giving out piccolo sounds.

### VISION — THE EYES

Now consider the eyes. Light rays from the sun bounce off all the objects around us, and some of those rays hit the light receptors in the back of our eyes, on the retina. The leaves on a tree absorb much of the light that strikes them, but the green light is reflected back. Those rays strike the retina, and we see the leaf as green. A red dress absorbs all the light except red. It reflects the red rays, and we are dazzled by the beauty of the bright red color of those reflected rays.

When a light receptor is triggered by a light ray it sends a message to the brain. What type of message is that? It is an electrical impulse, of the same type as the electrical impulses sent by the ear in response to the vibrations it received. So if the same electrical impulses carry information about sound waves and light rays, what prevents our brain from becoming confused? It is not confused for the same reason a computer knows the difference between a signal from the M key and a signal from the G key — the wires from those two keys go to different places in the computer. In the same fashion, nerves from the eye go to a specific place in the brain, and that part of the brain interprets them as light. The enormous number of receptors in the eyes are all connected by specific nerves to the brain, and the brain is programmed to interpret the spatial and color information coming from the light receptors, but all of the information reaches the brain as electrical impulses.

The retina has four broad classes of photoreceptors; one class for black-and-white vision, and three for color vision. The three classes of color receptors are sensitive to wavelengths corresponding to red, green and blue light respectively. Nerve networks in the retina of the eye do some preliminary analysis of the visual image, and then the many individual optic neurons are stimulated to send electrical impulses to the optic cortex, the vision processing center in the brain. The only reason the brain knows how to interpret the incoming electrical signals is because each different color receptor type, in each part of the eye, transmits its information over specific nerve connections to specific targets in the vision center. There pure colors and mixtures of colors are perceived as combinations of firing of these different receptor populations. The vision center processes this information by picking it apart into categories of information. It generates "layers" of information — information about color, about shape, information about motion, about visual depth, etc. These "layers" are superimposed upon each other to recreate the visual image. This can be compared to what happens in a computer-graphics package such as Adobe® Illustrator® or Jasc Paint Shop™ Pro®, that divides an image into multiple layers and superimposes them so we see a single integrated image.

Since long-wavelength light rays and short-wavelength light rays both communicate to the brain via the same type of electrical signals, the brain's mode of interpreting those signals is not predetermined by natural law, but is the result of instructions (like computer software) in the brain, programmed to interpret the electrical signals from each optical nerve and produce the correct visual image. Another way to say this, is that our perception of red or green colors is the result of an information processing system that is not predetermined by the laws of physics, but was designed by an intelligent Inventor.

One might argue that the wavelengths of light which produce various colors are well understood by physicists, and that it is very predictable which wavelength will be seen as which specific color. That statement is partly true. The spectrum of visible light wavelengths is the result of precise physical laws, and the way in which those wavelengths are selectively reflected by different substances is a very consistent feature of nature. It is also true that we can predict which wavelength of light will be seen by us as green — usually. But the exceptions are a key to unraveling this puzzle. The fact that most of us see green in response to the same wavelength only confirms that the brain is very reliably programmed — we can count on it to see green the same way all the time. But it is not that way for everyone; those who are color blind cannot tell distinguish red from green. When those individuals' eyes are stimulated by light, do the laws of physics change? Of course not, the wavelengths of light reflected from tree leaves are still the same. The difference is in the interpretation occurring in their brains and optical systems. For those persons the instructions for interpreting red and green wavelengths are defective, so their perceptions of the colors are quite different. Fortunately color blindness is not a common problem, and in the majority of cases is limited to red and green. This tells us that the light-interpreting center in the brain is usually extremely stable and reliable, but it still appears to be dependent on the organization of the brain. In other words, the colors we perceive are not specified by the laws of nature, but they result from the way the Creator designed our brains. Color, as we perceive it, only exists in animal species whose brain generates those perceptions of color. Thus the rainbow is all in our heads. Any type of light-detecting instrument we could possibly invent can only measure the wavelength of light, it has no way of knowing what colors we will perceive when our brain interprets those wavelengths.

Now reconsider the experiment we discussed before — unplugging the nerve cord from the ear and reversing it. This time, imagine we could unplug two nerve cords, one from the ear and one from the eye, and exchange them. Now the sound processor in the brain would be receiving electrical signals from the eye, and the visual processor is getting its electrical signals from the ear. What would we see and hear? We would "hear light" and "see sound!" The brain would no doubt be very confused, because the visual processor lacks the proper software to understand sound information. However, we would see some type of pattern, generated from the sound signals. We would also hear strange sounds!

One other aspect of vision is truly amazing, but we take it for granted. The eye can be compared to a camera, with a lens that focuses an image on the retina at the back of our eye. We do not see that image as a flat picture on the back of our eye. The retina only receives the light signals, which it sends to the brain, and the brain performs a feat that seemingly defies explanation. The brain projects our consciousness of the image out into space in front of us, and we see the image where the objects actually are. We see a tree trunk some distance in front of us as we walk through the forest, but there is no solid connection from the tree to us. We only perceive the light waves reflected from the tree, and unless we touch it physically, we are only seeing an image constructed by our brain, inside our head. Our brain puts together the visual signals received by our eyes, integrates them with other spatial information we have learned through experience, and generates a conscious perception of an image out there, exactly where the object really is.

Though this complex process is accomplished by our brain — so accurate and predictable that we have learned to trust it, and move aside before we run headfirst into the tree trunk. It is so accurate that a baseball player can process the constantly changing image of a little white ball sailing through the air at high speed, integrating that with speed and directional information sent from his legs to his brain, while running at top speed, further analyzing data on the location of his gloved hand, which is perhaps outside of his visual field part of the time, and is able to bring the glove into the path of the ball with a high degree of accuracy! No combination of physical laws alone can explain the brain's ability to analyze all that information, and project our consciousness of the image into space to where the ball really is — it is an intelligent information analysis system invented and placed into our brain by the Great Inventor.

A few people possess a curious ability that sheds more light on our brain's processing of visual information, and reveals the types of crossover that can occur in the brain between categories of signals that are usually distinct and separate. Our brain interprets spatial information, like the shapes and locations of the letters that you are reading. Since these letters are all black, they all look the same to you and me. Not so with some people, whose brains mix together shapes and colors so they see letters in color, with a given letter always having the same color (Cytowic 1989, Grossenbacher & Lovelace 2001, Ramachandran & Hubbard 2003; see also Beeli et al. 2005). If you hear two individuals arguing whether R is blue or green, you know they both have this rare condition, called synaesthesia.

### DOES A BAT SEE WITH ITS EARS?

Incredible brain processes are not confined solely to humans. Bats have an incredibly accurate sonar system. The bat gives out high-pitched cries, above our range of hearing. Those sounds strike objects and the echoes bounce off in all directions. A small percentage of the echo reaches the bat's ears, and the bat can determine from that echo exactly where the object is. Scientists have calculated the efficiency of bat sonar, compared to man-made sonar and radar systems, taking into account the weight of the system, how small an object it can detect, and the maximum distance from which it can detect that object. The bat's sonar is amazingly efficient. A bat in total darkness can avoid wires a tenth of a millimeter in diameter, catch tiny insects on the wing, and even distinguish between an insect and a little pebble the same size as the insect, using its sonar. Thousands of bats can fly side by side through a cave, all giving off high-pitched cries. Each bat can distinguish its own echo and navigate through the crowd.

One interesting question to ponder is what type of information is the bat sensing? Is it hearing echoes as sound, just like we hear echoes? Does it hear echoes and know how to interpret where that echo is coming from? Or does the bat's brain analyze these echoes and interpret them as a visual image? From what we have discussed so far, can you see that whether the bat "hears" the echoes or "sees" a visual image indistinguishable from the image created by its eyes is entirely a function of how its brain is programmed to interpret the electrical impulses reaching the brain? We do not know how to get inside a bat's brain and detect what it is seeing or hearing, but there is no physical reason why a bat might not produce a three-dimensional "visual" image from the information in the echoes from its echolocation cries. Maybe a bat does see with its ears!

### WHAT IS LOVE?

Think back to a memorable moment when you were standing hand in hand with someone you love, taking in the sounds and colors of a beautiful mountain scene. What is the source of the feelings of love and companionship that made the colors and sounds more vivid? What laws of nature specified those feelings, and the experiences, memories, and thoughts in your brain that were the foundation of those loving feelings? The tender touch of your loved one's hand only stimulated touch receptors and sent electrical signals to specific places in the brain. This clinical description does not sound very romantic!

If we stop there we understand physics and chemistry, but not love and romance. That whole experience of love was not predetermined by any laws of physics or chemistry. True, laws of nature hold together the molecules that make up our body, making life possible. But only your brain was able to know the meaning of that *particular* touch, and to generate a unique feeling, different from what would have been produced in response to a touch from some other soft but impersonal object or person. Friendship, companionship, and love are a beautiful system of relationships that depend on the information analysis system invented by the Creator and placed in our brains, just like the brain centers that control our perception of sound and color.

We believe love exists because the Creator loves us and wanted us to experience relationships that transcend mere physics and chemistry; relationships that bring to us the kind of joy and romance that only a personal God understands and can share with us to brighten our lives. Love is an invention from God, programmed into our brains. Love, like the rainbow, is all in our heads.

## THE GENIUS OF OUR SENSORY WORLD

Our entire sensory world of sounds, sights, colors, and smells and the magic of love is produced by the structural information in a brain, not only by the laws of sound or light waves. The next time you attend an orchestra concert, or sit at the edge of a forest in the evening, listening to the chorus of bird songs and watching the changing colors of the sunset blazing across the sky, think about the source of all this captivating sensory input. The varied instruments in the orchestra and the different types of bird songs are producing vibrations in the air, each in their unique ways, while refracted light rays of varying wavelengths produce the sunset. That is all fascinating physics in its own right, but it does not explain our appreciation of a symphony or a gorgeous sunset! The captivating sound of the symphony and intoxicating colors of the sunset are produced only by a brain. They are gifts that the Creator gave to us by way of the instructions and connections He programmed into our brain.

Electrical impulses are translated by the brain into exquisitely beautiful perceptions that we want to share with someone we love.

If a tree falls in the forest, and there is no one there to hear it, does it make a sound? No, it vibrates the air, but sound is only produced inside a brain.

## WHAT DOES IT ALL MEAN?

How did animals receive the equipment to generate sound, vision, smell, and romance? For over a hundred years science has been explaining this as the result of mutation and natural selection. Purely impersonal natural processes are believed by many to be the cause of all of our sensory abilities. But mutations do not know what an animal needs; they occur strictly by chance. It is proposed that along with many detrimental mutations, some mutations occurred which just happened to very slightly increase the analytical ability of our brain, and individuals with these improvements had a better chance of surviving. The theory of natural selection says that over long time periods, many of these individual, slight improvements added together to produce our amazing brain. In this view, there was no intelligent designer, but the apparent design was only produced by chance plus the creative action of natural selection (see, e.g., Dawkins 1986, 1996, 1998).

This article has discussed fascinating insights into the nature of sound, color, taste, beauty, love, and the Creator's inventive genius that produced them. This is opposed to the suggestion that these same senses arose from the impersonal natural processes offered by darwinian science. How can we be so sure we see the Creator's hand at work? Actually we can not prove it, just as no one can disprove it, but we believe it is a perfectly reasonable philosophical choice.

Science can contribute much toward understanding how our brains and other natural systems work. It can even discover the processes that make changes in animals, plants, and in brains. Science does best at understanding how things work, and the observable mechanisms behind changes that occur. Although there is abundant evidence for microevolution and the development of new species, there is a serious lack of convincing evidence for a genetic mechanism that could produce a new organ system or change one basic type of animal into another (Brand 1997, Spetner 1998). We cannot prove that it is impossible for a brain to evolve without an intelligent designer, but naturalistic science carries the heavy burden of convincing us that it could happen.

Many scientists puzzle over their lack of success in convincing the majority of people that a creator is not needed. They believe that evolution alone can produce living systems, including the brain with its abilities that seem to go far beyond the needs of survival, and they have difficulty understanding why so many others reject that conclusion. One reason for science's notable lack of success at convincing the majority of us to reject the Creator is that even the very best science lacks the evidence to demonstrate that impersonal natural processes can invent the brain with its ability to generate such a symphony of sound and sight and of romance that delights us and makes life beautiful (see references by Dembski and by Johnson on intelligent design).

In the modern scientific worldview the impersonal laws of chemistry and physics are the ultimate reality. But we believe God is a personal Being, and in His universe personal relationships are of ultimate importance. God is the inventor of the laws of nature and is the master of those laws, and uses them consistently to run the universe. But they are not His ultimate reason for creating, or His most valued creation. The laws of nature are only His servants, to provide a universe to support the more important realm — living, reasoning beings who can experience relationships.

Humans can never comprehend God until we understand and accept His nature as a personal Being to whom natural law is merely a means to support His highest priority in the universe — loving relationships, between Himself and beings who can share those trusting, loving relationships because they freely choose to do so.

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