Biology's Amazing Processes: Echolocation

Welcome back to the semi-regular Practical Science series "Biology's Amazing Processes." This week, we see - or more precisely hear - how species of bats and toothed whales sense prey and obstacles in their path using a very special ability called 'echolocation

PRACTICAL SCIENCE WITH PHIL FREDA

Echolocation is an amazing process which helps bats and toothed whales, which include the dolphins, pinpoint obstacles and prey.

If you have ever seen a dolphin on the Discovery Channel or have had the opportunity to see one at a place like Sea World, you have probably heard their signature clicks they make.
Did you know however, that these innocent clicks and squeaks are actually deadly weapons?

Whale/Dolphin Echolocation

Have you ever heard the expression, "art imitates life?"

Well, in some cases, humans imitate nature.

As far back as the time of Leonardo Da Vinci, humans have attempted to use sound in order to locate far or underwater objects.

According to Wikipedia, Da Vinci himself invented a tube, that when placed into water, was said to be used to detect vessels in the water.
Over many years, new types of equipment were manufactured to aid sailors and submariners in finding obstacles and enemies in the water.

Between 1916 and 1931, U.S. and British forces researched how to use sound in warfare. Finally in the 1930's, American engineers, after the production of British models, created what we call SONAR (Sound Navigation And Ranging).

What's interesting is that dolphins, whales and bats have been using this very type of system for millennia.

Dolphin and whale echolocation works in a very simple, but amazing, way.

Here is a breakdown of the process with help from howstuffworks.com.
First, the dolphin or whale uses nasal passages to make a high-pitched click, which is sent through a special organ in its head called the 'melon' (I know it's not a very technically term).

The squeak that the dolphin produces is usually so high pitched that we humans cannot even hear it.

According to hypertextbook.com, humans have a hearing range from about 20 to 20,000 Hz (Hertz). The dolphins produce a sound that is higher than this range and therefore we cannot hear it. This is similar to how a dog whistle works.
Anyway, back to the process.

Next, the sound that the dolphin produces eventually hits an object in the water. The sound waves bounce off the object and travel back toward the dolphin as an echo.

The sound waves are absorbed through the dolphin's jaw.

The dolphin's jaw acts as a tuning fork, moving the sound toward an area of fat. This fatty tissue further conducts the sound until it is exchanged, via chemical signaling, to nerve impulses.

These impulses are received and interpreted by the brain to give the object's size, distance, shape and material.

The ability to distinguish the material that an object is made of has lead researchers to train dolphins to detect certain metals that are used in making mines.

This amazing process is actually not fully understood by science.

It is apparent that these amazing creatures are using this ability, but it is not fully understood as to how the dolphin's brain interprets the signals it receives.

Unfortunately, echolocation leads to many dolphins being trapped in nets.

The material that fishing nets are constructed of do not produce echoes. This essentially makes the nets invisible to the dolphins, which means that they may actually swim right into them.

Fortunately, new nets are being created with a plastic beacon that does produce and echo so the dolphins can "see" and avoid the nets.

Bat Echolocation

The process for bats is very similar to dolphins.

Both creatures rely on producing sound waves that travel through some medium.

For bats the medium is air and for dolphins, it is water.

Sound waves are actually fluctuations in air pressure that push and pull air particles around the disturbance.

These sound waves are propagated like a chain reaction by disrupting the air particles around them. These air particles, in turn, disrupt more air particles and the process continues until it fades out.

Things that are much denser and heavier than air, like an insect's carapace or a rock, tend to deflect the direction of the sound wave back toward the source.

According to howstuffworks.com, you can actually calculate the distance between the source of the sound (you) and the point where the echo is produced.
If you are at sea level and the air is relatively dry, sound waves travel at 741 miles per hour or 0.2 miles per second.

Let's say you are at a place looking over a canyon and you start to shout. You hear your echo exactly three seconds after you started shouting. 0.2 miles times 3 is 0.6 miles.

This is the distance for a round trip across the canyon and back.

Half of 0.6 miles is 0.3 miles and that is the distance from where you are standing to the canyon.

This is basic principle that bats and dolphins use to find their prey. However, sound waves travel faster in water.

Bats emit their sounds the same way we humans do by forcing air past their vocal chords and out their mouths, or in the case of some bats, through their noses.

Most bats produce their sounds well above the human hearing range just like some whales and dolphins.

And, just like dolphins, the bat waits for the incoming echo and their brains figures out how far away the object is, what direction it is moving and how big it is.

If the object is an insect, the bat can determine which way it is flying. If the insect is moving away from the bat, the echo is at a lower pitch and if it is moving toward it, the pitch will be higher.

Some other creatures that use echolocation

Bats, whales and dolphins aren't the only creatures that use echolocation. Here is a list of other types of creatures with this amazing ability:

- Oilbird
- Swiftlets (Birds of the Genus *Aerodramus*)
- Shrews
- Tenrecs
- Humans!

That's right, humans!

One of the most famous people to use echolocation is an American named Ben Underwood.
Ben was diagnosed with retinal cancer at age 2 and had both of his eyes removed by the age of 3.

Ben discovered how to use echolocation at age five by producing clicking noises with his tongue. His echolocation abilities allowed him to do things like play basketball, run, rollerblade and even skateboard!

Sadly, Ben passed away Jan. 19, 2009 after a long battle with cancer.

Check out the Wikipedia site on human echolocation if you would like to see more people that have used echolocation.
Echolocation is an amazing ability and is truly one of biology's amazing processes.

As always, think about it and thanks for reading!