On the (sound) track of anesthetics

Physics explains biology
Every medical and biological textbook says that nerves function by sending electrical impulses along their length. ”But for us as physicists, this cannot be the explanation. The physical laws of thermodynamics tell us that electrical impulses must produce heat as they travel along the nerve, but experiments find that no such heat is produced,” says Associate Professor Thomas Heimburg from the Niels Bohr Institute at Copenhagen University. Instead, nerve pulses can be explained much more simply as a mechanical pulse. And such a pulse could be sound.

Sound versus electricity
Normally, sound propagates as a wave that spreads out and weakens. If, however, the medium in which the sound propagates has the right properties, it is possible to create localised sound pulses which propagate without spreading or losing their strength.

The membrane of the nerve is composed of lipids, a material that is similar to olive oil. This material can change its state from liquid to solid with temperature. Molecules that dissolve in membranes can lower the freezing point of membranes. The scientists found that the nerve membrane has a freezing point, which is precisely suited to the propagation of these concentrated sound pulses. Their theoretical calculations lead them to the same conclusion: Nerve pulses are sound pulses.

Anesthetised by sound
How is it possible to operate on a patient without pain? It has been known for more than 100 years that substances like ether, laughing gas, chloroform and the noble gas xenon can serve as anesthetics. These substances have very different chemical properties, but experience shows that their doses are strictly determined by their solubility in olive oil. In spite of this, no one knows precisely how anesthetics work and how the nerves are ”turned off”.

If a nerve is to be able to transport sound pulses and send signals, the membrane's melting point must be sufficiently close to body temperature. The effect of anesthetics is simply to change the melting point – and when the melting point has been changed, sound pulses cannot propagate. The nerve is put on stand-by, and neither nerve pulses nor sensations are transmitted. The patient is anesthetised and feels nothing.

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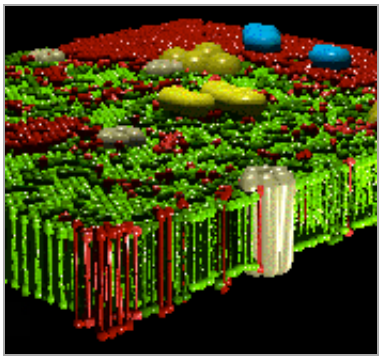

The figure shows a biologiccal membrane at its melting point. The green molecules are liquid, and the red are solid. Molecules of anesthetics reduce the number of red areas so that the sound pulse can no longer transport its signal. The nerve is anesthetised.

Illustration by Heiko Seeger, PhD.

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