MEDICAL PHYSICS

2-1 The structure of the ear

1. When sound waves make the ear drum vibrate, the vibrations are transmitted to the oval window of the inner ear by three bones called the hammer, anvil and stirrup. The bones act as a lever system amplifying the force of the vibrations by about 50%.

2. (a) The ear automatically responds to excessively loud noise by slackening the muscles holding the bones of the middle ear together. They vibrate differently and transmit sound energy less efficiently.

(b) Temporary deafness occurs when the muscles remain slack after being in a noisy environment. Hearing returns when the muscles become taut again.

3. Pressure on eardrum = 2.0×10^{-5} Pa

Eardrum area = 50 mm^2 = 50×10^{-6} m^2

Force amplified 50% by the bones of the middle ear

(a) Pressure = $\frac{\text{Force}}{\text{Area}}$ or P = $\frac{F}{A}$ so P = FA = $2.0 \times 10^{-5} \times 50 \times 10^{-6}$ N = 1.0×10^{-9} N

(b) Area of oval window = 3.0 mm^2 = 3.0×10^{-6} m^2

Bones amplify the force by 50% so force on oval window = 150% of 1.0×10^{-9} N = 1.5×10^{-9} N

Pressure = $\frac{\text{Force}}{\text{Area}} = \frac{1.5 \times 10^{-9}}{3.0 \times 10^{-6}}$ = 5.0×10^{-4} Pa

4. (a) (i) The oval window transmits vibrations from the middle ear to the inner ear.

(ii) The basilar membrane vibrates stimulating 'hair cells' on it to send nerve impulses to the brain

(iii) The round window enables vibrations to leave the inner ear

(b) If the area of the oval window was greater than 3 mm^2 then the pressure exerted on it would be less as the pressure from the eardrum would be amplified less.

The would make the ear less efficient at detecting quiet sounds that exerted little pressure.