Citation:

W. Einthoven, On a third heart sound, in:
KNAW, Proceedings, 10 I, 1907, Amsterdam, 1907, pp. 93-95

wall of the brain-vesicle. These cells I mean to describe in my second paper.

Leiden, 25 April '07.

DESCRIPTION OF FIGURES ON THE PLATE.

All the figures are magnified 1600 times, and are drawn with a camera lucida of ABBE directly after the preparations. Apochrom. oil-immersion lens of ZEISS and compens-ocular No. 8.

Fig. 1. Colossal nerve-cell with neurofibrillar network, of a Branchiostoma of 4.8 cM. in length (BIELSCHOWSKY—POLLACK's method).

„ 2. Dendrites of a similar cell of an animal of 5 cM. in length (same method).

„ 3. Neurofibrillar network of a colossal nerve-cell of a Branchiostoma of 6 mM. in length.

„ 4 *a* and *b*. Sections of a medium-sized nerve-cell of the same spinal cord as fig. 2.

„ 5. Section of a very small nerve-cell, with neurofibrillar network.

„ 6. The same as in fig. 4.

„ 7. Section of a sensory cell of Pontobdella, of 10μ, treated after the gold-method of APATHY.

„ 8—11. Sections through different cells of the dorsal group of cells lying behind the brain-vesicle, taken from preparations of several adult specimens of Branchiostoma. In fig. 8 some of the adjoining cells are drawn, to demonstrate the similarity of structure of the nuclei in the two cell types.

In fig. 10 and fig. 11 are drawn two typical sections through cup-shaped cells of the dorsal group of cells. The body contained in the centre of the cell of fig. 11 is the prolongation of the glious basket surrounding the cell. Compare fig. 10.

Physiology. — *"On a third heart sound"*. By W. EINTHOVEN, in collaboration with Messrs. J. H. WIERINGA and E. P. SNIJDERS, assistents at the physiological laboratory at Leyden.

When continuing the investigation of the heart sounds by means of the string galvanometer [1]), we noticed that in some cardiophonograms, especially with the apex sounds of W i, recorded in February last, shortly after the vibrations of the second sound still another vibration was present, which admitted of no other interpretation than by regarding it as a third heart sound.

We could not at once explain how this third sound was produced, and we put off the closer investigation of this phenomenon, however

[1]) See: Die Registrirung der menschlichen Herztöne mittels des Saitengalvanometers. PFLÜGER's Arch. f. d. gesammte Physiol. Vol. 117, p. 461, 1907.

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interesting it seemed to us, since for the present our time was taken up by other work.

A couple of months afterwards Dr. A. G. GIBSON of Oxford — to whom our former publications on the recording of heart sounds were known, but who could not be acquainted with our later observations — asked whether in our collection of cardiophonograms of normal persons there were any in which an extra sound was visible in the diastolic phase. GIBSON occupied himself with an investigation of the venous pulse [1]) and had noticed that with some persons, without a morbid affection of the heart, a low pitched sound could be heard at the apex during the cardiac pause, something like a distant 2nd sound, but feebler and much lower in pitch. The sound is clear and nothing like a murmur. This particular sound is of varying intensity being louder during the interval between the end of an expiration and the beginning of the subsequent inspiration.

We hope elsewhere to publish in a more extensive paper the cardiophonograms we obtained; here we shall only deal briefly with them. When we try to predict from the shape and dimensions of the curves what impression the third heart sound must make on the ear of the observer, we cannot describe it otherwise than GIBSON did: a distant diastolic sound of low pitch and clear tone, varying in intensity, but always feeble.

There can be no doubt that the sound, heard by GIBSON at Oxford, is the same sound we recorded at Leyden.

The measurements made with some cardiophonograms, show that with W i the beginning of the third sound falls on the average 0.13 sec. (varying between 0.11 and 0.15 sec.) after the beginning of the second sound and on the average 0.32 sec. before the beginning of the following first sound. In the same curves the duration of the first sound is about 0.08 sec., of the second about 0.05 sec., of the third 0.02 to 0.03 sec. The first two sounds are murmurs, composed of tones of irregular pitch. The mutual distance of some tops in the curves shows that we have here tones of more than a hundred double vibrations per second, whereas the third sound seems to be built up of but one double vibration, the period of which amounts to about 0.02 sec.

The intensity of the third sound varies. While in some cardiac beats it is entirely absent, the amplitude of its vibrations reaches in other beats 1/7 of that of the first and second sounds. Putting the

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1) GIBSON's investigation will shortly be published in "The Lancet" under the title: "The significance of a hitherto undescribed wave in the jugular pulse".

ratio of the amplitudes of the first or second sound to that of the third $a = 7$, and the ratio of the frequencies $b = 2$, the ratio of the intensities is $a^2 b^2 = 196$. Hence the third sound is at its maximum still about 200 times feebler than the first or second.

While the above given figures refer to the objective intensities, a comparison of the intensities of perception is still much less in favour of the third sound, since a tone of frequency 50 per second has objectively to be a little over a hundred times stronger [1]) than a tone of 100 vibrations a second, in order to produce an equally strong auditory impression. Consequently, if the third sound attains such an intensity that it is just audible still, the first and second sounds may be 20.000 times weakened, before also the auditory impression they produce, vanishes.

This explains the difficulty of the investigation by the method of auscultation. GIBSON [2]) emphasises this particularly and says that in order to hear the sound, accidental sounds must be excluded as much as possible, while one has to strain one's attention during the interval in which the sound occurs. Although the cardiophonograms leave no doubt as to the existence of the third heart sound with W i, we have been unable to hear it by means of a stethoscope.

Regarding the explanation of the third sound we refer to the above mentioned more extensive paper which will shortly be published elsewhere. Here we will only state our conclusion that the sound cannot be put on a line with a prae-systolic murmur of the mitral valve, nor with a duplication of the second sound by non-simultaneous action of the aortal and pulmonal valves, but that it is probably caused by a second vibration of the valvulae semilunares aortae and must be regarded as a phenomenon of pretty common occurrence.

Astronomy. — "*On some points in the theory of Jupiter's satellites.*" By Dr. W. DE SITTER. (Communicated by Dr. E. F. VAN DE SANDE BAKHUYZEN).

The following pages contain a short account of some investigations, which will soon be published, together with other results, in N°. 17 of the publications of the astronomical laboratory at Groningen.

A few words are necessary in explanation of the notations em-

[1]) Calculated according to MAX WIEN, PFLÜGER's Arch. f. d. gesammte Physiol. Bd. 97. p. 1. 1903. H. ZWAARDEMAKER and F. H. QUIX give in ENGELMANN's Arch. f. Physiol. p. 25. 1904, differences in the same sense, but of a different order of magnitude.

[2]) l. c.