larval instars, which represent secondarily introduced phases of development.

On quite different grounds the same assertion has been defended by DEEGENER (1909).

Considering the regular occurrence of a macula dorsolateralis on the pupa situated between m. dorsalis and m. suprastigmalis (even when a seta dorsolateralis is wanting on the abdominal segments of the larva), the pupa may be said to have best preserved the original hexapodal colour-design of the insect, at least in this instance and in the ornamentation also the thoracic segments which in other respects have been so profoundly modified.

The Hague, March 1917.

Physiology. — *"Distance-relations in the Effects of Radium-radiation on the isolated Heart"*. By Prof. H. ZWAARDEMAKER.

(Communicated in the meeting of March 31, 1917).

The results of 34 initial experiments [1]), justified the present writer in establishing that an isolated frog's hart, fed after KRONECKER's method with RINGER's mixture deprived of potassium chloride, resumes its beats again after a standstill when exposed to the radiation of mesothorium or radium. [2]) We used 6 mgrms of mesothorium enclosed in a glass bulb and 3 mgrms of radiumbromide under mica. On an average an exposure of half an hour was required for the restoration of the pulsations. [3])

Then however a good and regular contraction recommenced, the rhythm being about the same as when the heart was not yet freed from the circulating potassium. The mesothorium-tests were also successful when the rays had to pass through an aluminium screen 0.2 mm. thick.

In the meeting of February I could also demonstrate that potassium and rubidium, when either of them is contained in the

[1]) H. ZWAARDEMAKER, C. E. BENJAMINS and T. P. FEENSTRA, Radium-radiation and cardiac action. Ned. Tijdsch. v. Geneesk. 1916 II p. 1923.

[2]) The previous removal of potassium from the circulating fluid is very essential, for exposure of the heart in situ or perfused with normal RINGER's mixture, does not alter the actual beats materially.

[3]) The intervals between the commencement of the exposure to radiation and the recurrence of pulsation differ very much. They depend on the velocity of perfusion, the natural frequency of pulsations, the time the inactive circulating fluid needs to cause a standstill, etc.

circulating fluid, are neutralised by uranium, thorium, radium, or emanation. To this series the radiation may be added, on the side of potassium and rubidium. Its effect may be neutralised when uranium or thorium are contained in the circulating fluid.

This led me to investigate the quantitative relations coming to the front when placing a mesothorium preparation of 5 mgrms in a glass bulb at various distances and when to a neutral mixture of 40 mgrms of potassium chloride and 10 mgrms of uranylnitrate the quantum of uranyl-salt, required for each distance, was added. [1])

Let us consider a frog's heart through which after the method of KRONECKER has been sent first RINGER's mixture and subsequently, for some time, a potassium-free circulating fluid composed of 7 grms sodium chloride, 200 mgrms of calcium chloride and 200 mgrms of sodium bicarbonate per litre. At a certain moment this inactive circulating fluid is replaced by one similarly composed to which has been added 40 mgrms of potassium-chloride and 10 mgrms of uranylnitrate. The heart thus supplied will soon lose its contractility. Next the preparation of 5 mgrms of mesothorium (in a glass bulb) is placed at a distance of precisely 8, 7, 6, 5, 4, 3, 2, 1 mm and we wait for the recommencement of the heart's beats, which on the average will take place after 13 minutes (minimum 1, maximum 60 minutes). Now some uranyl nitrate in excess is added to the circulating fluid in a solution containing 1 mgrm of uranium salt per c.c. This procedure is continued for some time along with the radiation until the heart stops again. In this case a slight touch will engender one systole. Should there be a short series at first then the wanted equilibrium is not yet obtained and a little more uranium has to be added. At length a standstill will ensue and may be maintained for 5—10 minutes (we took 5 minutes with a comparatively quick flow and 10 minutes with a tardy one).

The looked for equilibrium between radiation on the one hand and uranium in excess in the circulating fluid on the other was found at the following distance (See table p. 1163)

The equilibruim once established the relations may be altered again. The mesothorium may be moved nearer to the heart, or a larger quantum of uranium salt may be added. Either process is responded to by the heart's contraction and a second equilibrium may be looked for. In this way we often succeeded in finding even three successive equilibria.

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[1]) I have to thank Mr. T. P. FEENSTRA assistant in the Phys. Lab. for his painstaking assistance in these experiments.

Distance between mesothorium and the heart (mm).	Uranyl nitrate added to the primary mixture (mgrms).
8	2 (?)
6	5,5
5	7
4	8
3	12
2	20
1,5	30
1	40

When representing the data of the table graphically we get a curved line reminding one of an exponential curve. I, therefore, plotted the distances along the axis of the abscissae and along the axis of the ordinates the logarithms of the mgrms of uranium salt present in the successive equilibria over and above the 10 mgrms that from the outset were present along with 40 mgrms of potassium chloride per litre of circulating fluid. The curve thus originating is represented in the graph by a firm line.

As the figure points out the curve of the logarithms of the uranium dosage, counterbalancing the radiation, is approximately straight. A slight deviation is noticeable only for the greater distances.

This result is not what could be expected: alpha-rays do not come into play here, as the restoring influence is exerted through an aluminium screen of 0,2 mm and even a leaden screen of 0.1 or 0.2 mm. Of the remaining beta-rays much is absorbed in the heart, as was shown when the heart was contained in the leaden roof of a small ionising-chamber. The gamma-rays passed almost unchecked.

There are additional reasons for stating that the beta-rays in casu are biologically active. From the experiments just described it follows that the essential part is to a great extent absorbed by the air.

Already at the distance of 9.5 mm the quantum liable to be compensated by uranium is spent. At 6 mm only an equivalent of an extra addition of 5 mgrms of uranyl nitrate per litre, is present: the very quantum transmitted through a 0,2 mm aluminium screen placed at close distance [1]).

[1]) A radium preparation of 3 mgrm. has a uranium equivalent through an aluminium screen of 0,1 mm. In considering such values we should of course also

The excitation of fresh contractions of a heart, fed with a totally inactive circulating fluid (potassium-free RINGER's mixture) or with a fluid containing correctly proportioned antagonistic quanta of potassium and uranium is, therefore, to be ascribed to a broad bundle of beta-rays of very low penetrating power. That this non-homogeneous mass of weak rays should be absorbed in the air according to an almost exponential law is not in the least surprising. Nor is it to be wondered at that subsequently what comes through the air from various distances is completely absorbed in the organ. The foregoing experiments also show that the quanta of uranium, which at the several distances counteract the restoring influence of the radiation so that the heart's contractions excited by the mesothorium cease again, are subject to the same quantitative law the absorption of the radiation has to obey. As the distance increases these uranium quanta should be diminished in such a sense that their logarithm remains inversely proportional to the distance.

The qualitative relation induces me to assume that the biologically active quantum of energy shot out from the mesothorium in its weak beta-radiation, and the uranium dosage, required for the equilibrium, and arresting the contractility of the heart, are antagonistic. The radiation as well as the radio-active substance sent into the heart are to derive their activity from the mutually compensating energies carried along with them.

The character of the weak beta-rays, in which lies the whole gist of the matter, seems to be rather well defined by the above, at least when, as is the case in our experiments, the restoring influence is considered. An obliterating influence is effected also by the more penetrating rays and perhaps it may be for the very reason that we cannot get rid of them, that the recovery, obtained through artificial radiation, was always transitory, never persistent.

The following equilibria are obtained when working with a radium-preparation of 3 mgrms in the same way as has been described above for the mesothorium-radiation. This preparation yields the advantage of a more even area of radiation. (See table p. 1165).

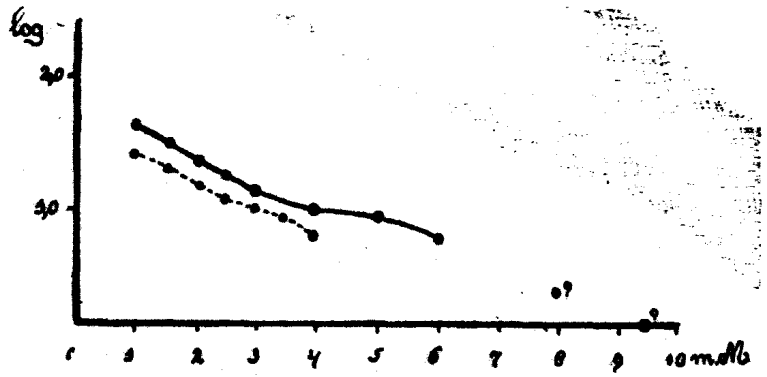
We will also graphically represent these data by plotting the distance along the axis of the abscissae to the logarithms of the uranium doses as ordinates.

This gives a curve represented by the dotted line which again may be considered as approximately straight.

It is obvious that by extrapolating mentally towards the ordinate

take into account the secondary rays of very low penetrating power that are generated in passing through the screen.

Distance between radium and heart (mm.)	Uranyl-nitrate added to the primary mixture (mgrms.)
4	5
3,5	6,5
3	9
2,5	11,5
2	15
1,5	18
1	22



——— Mesothorium-equilibria — — — — Radium-equilibria.

0 a method may be found to determine the biological value of a radio-active preparation (in a recovering sense). But it is out of place here to deal with this practical application.

Botany. — "*The influence of light- and gravitational stimuli on the seedlings of Avena sativa, when free oxygen is wholly or partially removed*". By Dr. U. P. v. AMEIJDEN. (Communicated by Prof. F. A. F. C. WENT).

(Communicated at the meeting of February 24, 1917).

§ 1. *Introduction.*

Our conception of the influence of oxygen removal on geotropism and phototropism is mainly due to CORRENS [1]). His method of working

[1]) C. CORRENS. Ueber die Abhängigkeit der Reizerscheinungen höherer Pflanzen von der Gegenwart freien Sauerstoffes. Flora 75. 1892.