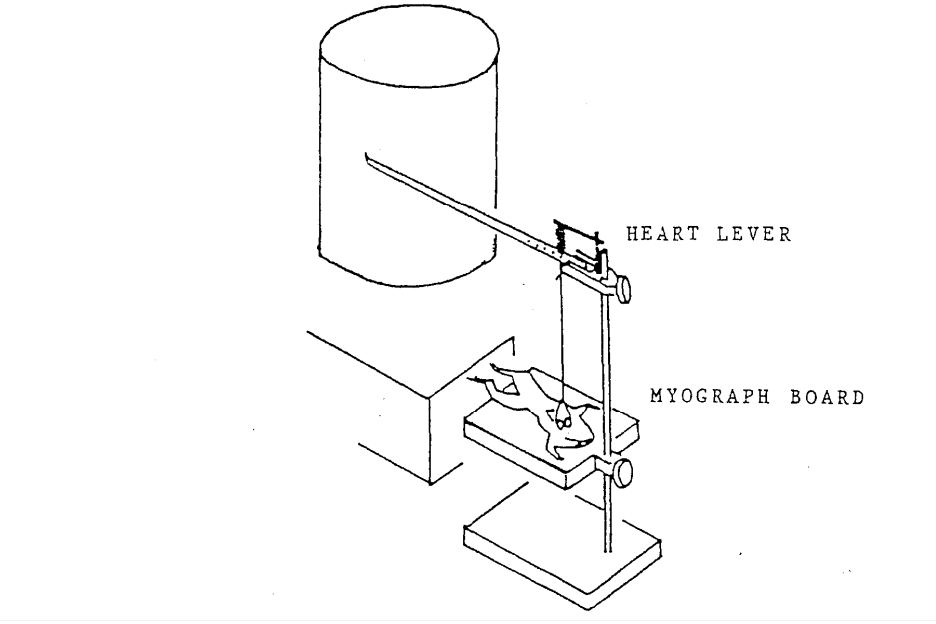
UNIT XIV
Frog Heart Physiology



Properties of heart muscle

- ***Learning Outcomes:***

  By the end of this session you should be able to:

  - Handle living tissue so that its activity is preserved.
  - Show that the heart is capable of continued beating provided that the appropriate ions and nutrients are present.
  - Explain the effects of temperature and the autonomic neuro-transmitters, acetylcholine and noradrenaline, on the heart rate.
  - Understand the ‘all-or-nothing’ response of excitable tissues to electrical stimulation.

Pithing Frogs

- Pithing involves the destruction of the central nervous system.
- After this process, all reflex activity, particularly the eye and the leg withdrawal reflex of the frog, should be absent.

The Frog heart preparation

- **Apparatus**
  - Universal Kymograph with Stimulator.
  - Recording Drum.
  - Starling Heart Lever with Lever Extension Writing Point. .
  - Heart Clip.
  - Electrode Pair.
  - Strong Pins, Thread etc.
  - Frog Ringer solution and drug solutions
  - Ink:Glazed or Chart Paper Plastic Ink Pen

Frog Heart Physiology

- This experiment studies the cardiac cycle of the frog heart noting the site of origin of the heart beat, how it is controlled and how the contractions of the different chambers of the heart are coordinated

Cont.

- The frog heart, like other vertebrate hearts, is inherently rhythmic so that it continues to beat as long as the circulation is intact.
- The electrical signal which initiates the heart beat arises in pacemaker cells in the tissue of all the major chambers of the heart.
- The membrane potential of these cells fluctuates spontaneously and when their depolarization reaches the threshold value, action potentials are generated which are propagated amongst the muscle cells to initiate their contraction.

Cont.

- Those pacemakers which generate action potentials at the highest frequency, dominate the rhythm, as the refractory period of heart muscle is such that the other pacemakers are ineffective unless the conduction of the main pacemaker signal is blocked.
- The rate of pacemaker depolarization, and therefore of the heart beat, is controlled by the autonomic nervous system and by the endocrine system.

Cont.

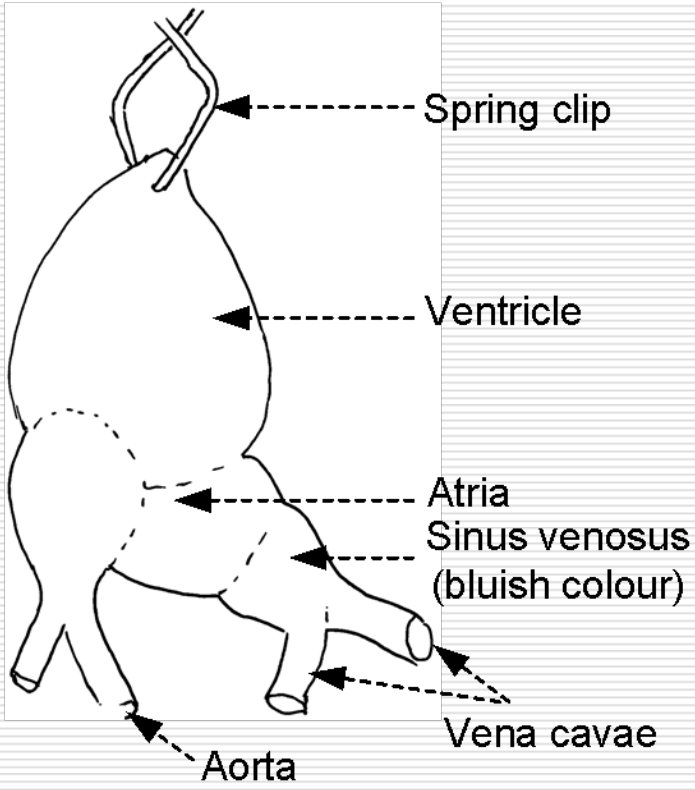
- Parasympathetic nerve fibers which originate in the medulla pass to the heart in the vague nerve.
- These fibers release acetylcholine when stimulated and cause a reduction in the heart rate.
- There is some doubt whether sympathetic accelerator fibers are found in the frog, however in other vertebrates nor adrenaline, released by these fibers, accelerates the heart.
- In common with other vertebrates, the frog heart is accelerated by the application of the hormone adrenaline.

Preparation of the heart

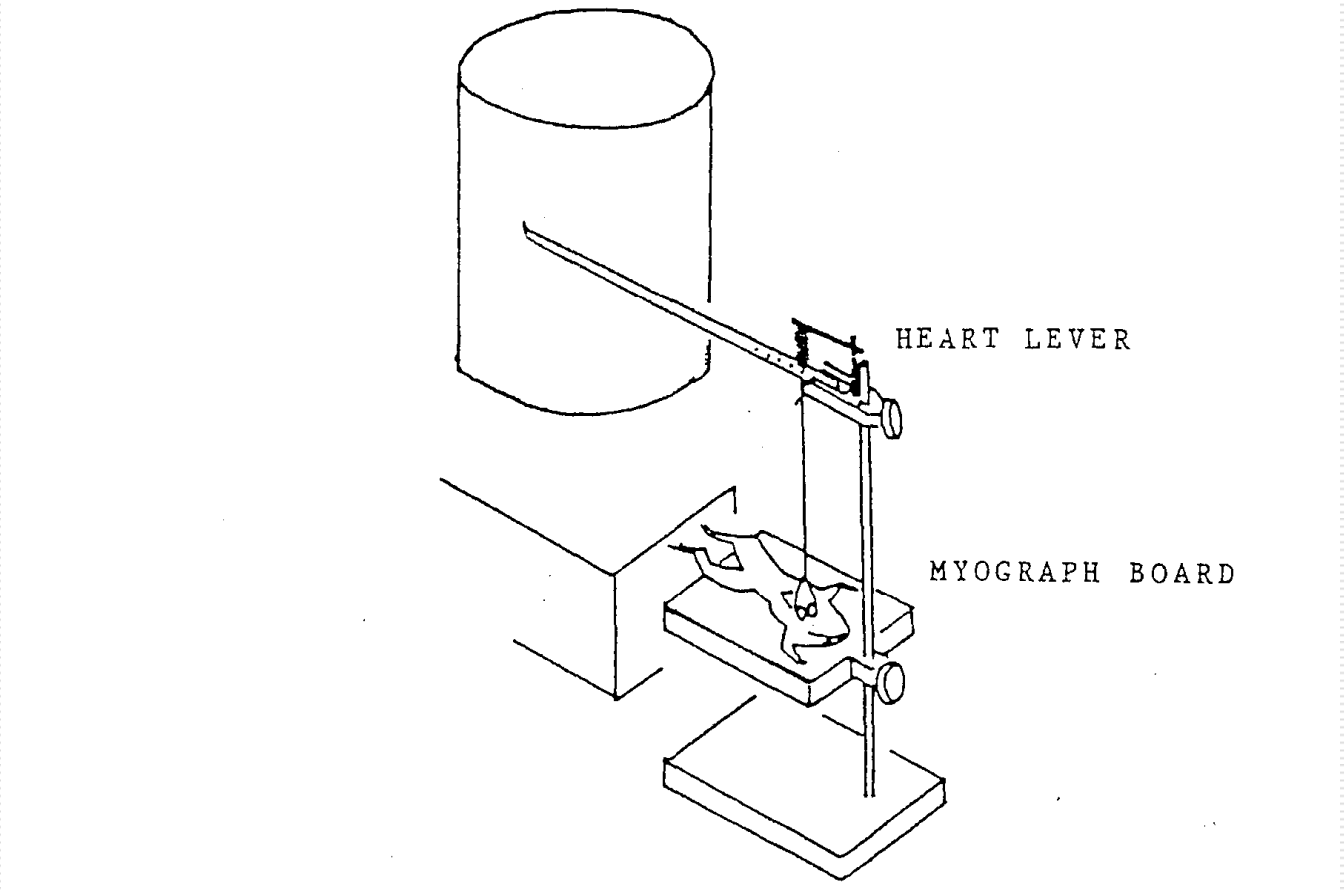
1. Tie about 200 mm of thread to the spring clip.
2. Place the frog, which has had all the central nervous system destroyed, on its back and open the body cavity along the mid-line with scissors.
3. Insert one blade of the scissors and cut through the pectoral girdle on each side of the sternum, Remove the sternum.
4. Cut the pericardium without damaging the heart inside.

5. Gently raise the ventricle with the fingers (not forceps) and catch the tip of the ventricle in the jaws of the spring clip, taking into the clip no more of the ventricle than is necessary to prevent it tearing out on gentle traction.
6. Lift the ventricle by means of the thread and divide the fine pericardial ligament connected to its posterior surface.
7. Place the frog in position with the heart directly under the lever of the transducer. Slide the transducer downwards and tightly tie the tread to the transducer lever with a double knot.

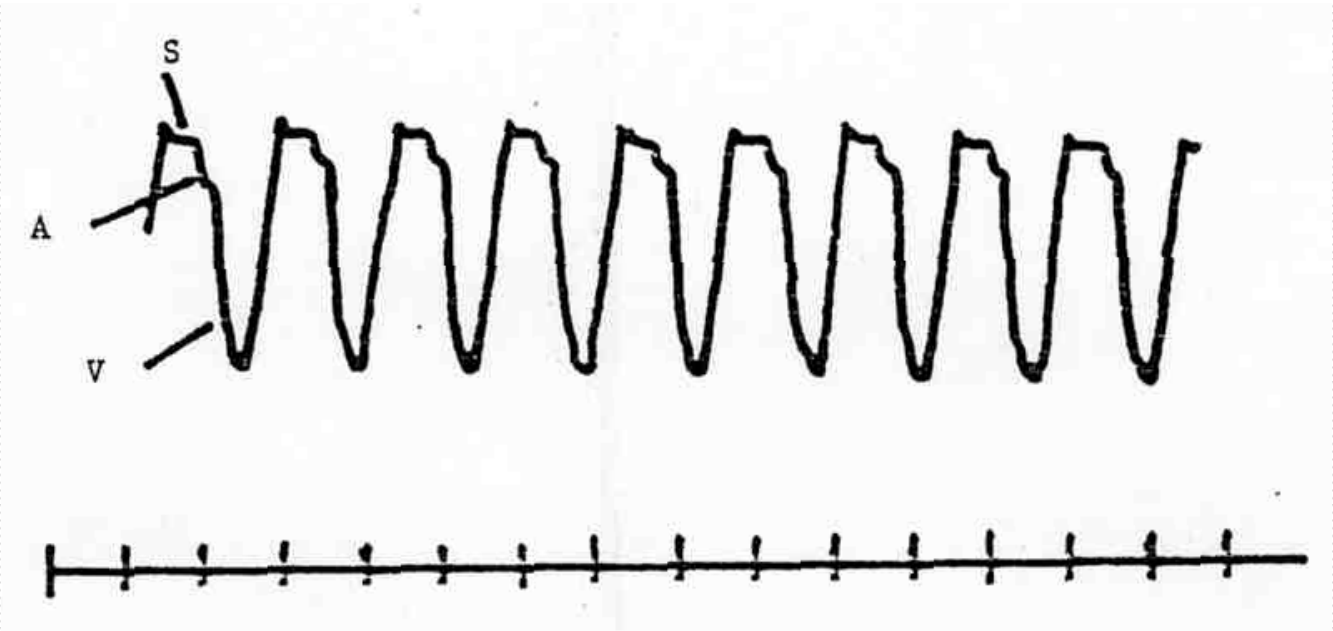
Frog heart (looking towards the head of the animal)



Apparatus to record the response of the frog hear



A typical record of the frog heart



A typical record of the frog heart beat showing sinus (s) auricular, (a) and ventricular (v) beats. (Drum Speed 5 mm/sec.)

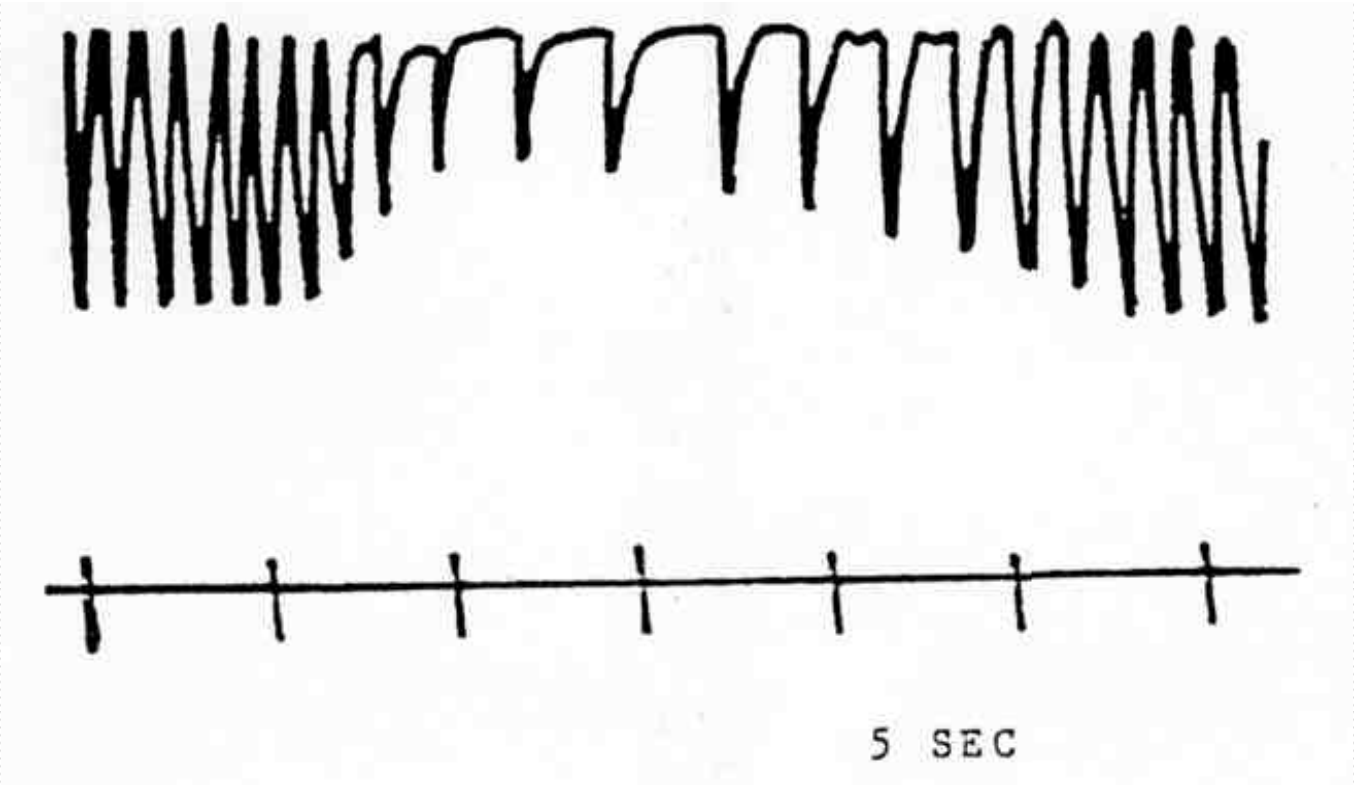
The Effects of Temperature

- Reduce the kymograph speed to 2 mm/sec. and record the normal heart beat.
- Irrigate the heart with cold Ringer solution and note any changes in its rate.
- Return the heart to room temperature with normal Ringer solution and when the original rate is re-established repeat the observation using warm Ringer.

The Effects of Acetylcholine

- Irrigate the preparation with a solution of acetylcholine in Ringer: note the effects of the drug on
  - a) The heart rate and
  - b) The strength of the contraction
  - Allow the drug 30 sees. for its action to be fully demonstrated.

The Effects of Acetylcholine



The Effects of Atropine and Adrenaline

- Wash the heart with fresh Ringer.
- Now try the effects of atropine followed by acetylcholine.
- Does atropine alter the hearts response to acetylcholine?
- Wash the heart thoroughly with Ringer until a normal response is seen.
- Irrigate the heart with adrenaline. Note any effect on the rate and strength of contraction..

Excitability

- **stimulation of the arrested heart:**
  - If the heart stops completely, due to lack of "pacemaker" activity, it can still beat if stimulated electrically.