D4: The heart
<table>
<thead>
<tr>
<th>Statement</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.4.U1</td>
<td>Structure of the cardiac muscles cells allows propagation of stimuli through the heart wall.</td>
</tr>
<tr>
<td>D.4.U2</td>
<td>Signals from the sinoatrial node that cause contractions cannot pass directly from atria to ventricles</td>
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<tr>
<td>D.4 U3</td>
<td>There is a delay between the arrival and passing on of a stimulus at the atrioventricular node.</td>
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<tr>
<td>D.4 U4</td>
<td>This delay allows time for atrial systole before the atrioventricular valves close.</td>
</tr>
<tr>
<td>D.4.U5</td>
<td>Conducting fibres ensure coordinated contraction of the entire ventricle wall.</td>
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<tr>
<td>D.4.U6</td>
<td>Normal heart sounds are caused by the atrioventricular valves and the semilunar valves closing causing changes in blood flow.</td>
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<tr>
<td>D.4.A1 Use of artificial pacemakers to regulate the heart rate.</td>
<td></td>
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<tr>
<td>D.4.A2 Use of defibrillation to treat life-threatening cardiac conditions.</td>
<td></td>
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<tr>
<td>D.4 S1 Measurement and interpretation of the heart rate under different conditions</td>
<td></td>
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<tr>
<td>D.4 S2 Interpretation of systolic and diastolic blood pressure measurements</td>
<td></td>
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<tr>
<td>D.4 S3 Mapping of the cardiac cycle to a normal electrocardiogram (ECG) trace.</td>
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<tr>
<td>D.4 S4 Analysis of epidemiological data relating to the incidence of coronary heart disease.</td>
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</tbody>
</table>
Nature of Science: The Invention of the stethoscope

Developments in scientific research followed improvements in the apparatus or instrumentation: the invention of the stethoscope led to improved knowledge of the workings of the heart.

YouTube:
https://www.youtube.com/watch?v=0bxiOMJAMW8&t=2s
Cardiac Muscle cells

Khan Heart Cells
(up until 7:00mins)
Cardiac muscle cells

Muscle fibrils, or myofibrils, are crossed by transverse tubules.

- These tubules mark the division of myofibrils into contractile units = sarcomeres
<table>
<thead>
<tr>
<th>SMOOTH</th>
<th>CARDIAC</th>
<th>SKELETAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Wall of hollow organs, vessels, respiratory passageways</td>
<td>Wall of heart</td>
</tr>
<tr>
<td><strong>Cell characteristics</strong></td>
<td>Tapered at each end, branching networks, nonstriated</td>
<td>Branching networks; special membranes (intercalated disks) between cells; single nucleus; lightly striated</td>
</tr>
<tr>
<td><strong>Control Action</strong></td>
<td>Involuntary Produces peristalsis; contracts and relaxes slowly; may sustain contraction</td>
<td>Involuntary Pumps blood out of heart; self-excitative but influenced by nervous system and hormones</td>
</tr>
</tbody>
</table>
Similarities between Cardiac and Skeletal muscle

- Like skeletal muscle, cardiac muscles are *striated* in appearance
- Similar arrangement of *contractile proteins* (actin and myosin)
Ways that Cardiac muscle differs from skeletal muscle

1. CM shorter and wider than SM
2. Long refractory period
3. CM contractions are brief twitches as opposed to long smooth contractions
4. Gap junctions exist
5. Cardiac muscle is self excitatory (not under voluntary control as compared to SM)
3D Heart Structure
Signal conduction in the heart

Sinoatrial (SA) Node (aka pacemaker) initiates contraction of cardiac muscle cells

→ AV node delays movement of the electrical signal by nearly 0.12s

→ Purkinje fibres conduct the signal very rapidly to the ventricles.
Specializations in AV Node

1. **Smaller diameter** and do not conduct as quickly
2. **Reduced # of Na+ channels** in the membranes of AV Node cells
   a. Greater resting potential
   b. Prolonged refractory period
3. **Fewer gap junctions** between cells of AV node
4. **More non-conductive tissue** present
Coordination of contraction

Modifications to Purkinje fibres

1. Relatively fewer myofibrils
2. Bigger diameter (faster conduction)
3. Higher densities of voltage-gated sodium channels
4. High numbers of mitochondria and glycogen stores
Systole vs Diastole

Systole = contraction of heart chambers

Diastole = relaxation of heart chambers
Review: The Cardiac Cycle (pg 300)

1. Atrial and ventricular diastole
   - AV valves open
   - Semilunar valves closed

2. Atrial systole, Ventricular diastole
   - AV valves closed
   - Semilunar valves open

3. Ventricular systole, Atrial diastole
   - AV valves open
   - Semilunar valves closed

Time:
- 0.1 sec
- 0.3 sec
- 0.4 sec
## The Cardiac Cycle

<table>
<thead>
<tr>
<th>DIASTOLE</th>
<th>ATRIAL SYSTOLE</th>
<th>VENTRICULAR SYSTOLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atria and ventricles relaxed</td>
<td>Atria contract</td>
<td>Atria relaxed</td>
</tr>
<tr>
<td>Blood flows into heart from veins</td>
<td>Ventricles relaxed</td>
<td>Ventricles contract</td>
</tr>
<tr>
<td>AV valves open</td>
<td>Blood pushed into atria</td>
<td>Blood pushed into arteries</td>
</tr>
<tr>
<td>SL valves closed (heart sound 2)</td>
<td>AV valves open</td>
<td>AV valves closed (heart sound 1)</td>
</tr>
<tr>
<td></td>
<td>SL valves closed</td>
<td>SL valves closed</td>
</tr>
</tbody>
</table>

Figure 4 The pressure changes inside the heart during the cardiac cycle.
1. Atria contract, atrio-ventricular valves open, blood moves into ventricles, semi-lunar valves close
2. Ventricles contract, pressure rises, a-v valves close, s-l valves open, blood pumped to arteries, atria refilled by veins
PQRST Wave

1. Pacemaker generates wave of signals to contract.
2. Signals are delayed at AV node.
3. Signals pass to heart apex.
4. Signals spread throughout ventricles.

SA node (pacemaker) → AV node → Bundle branches → Heart apex → Purkinje fibers

ECG
Read and take notes on skeleton notes

Look at...

Normal Sinus Rhythm

Sinus Tachycardia

Sinus Bradycardia

What is similar? What is different? Look at version II (typically on the bottom of the ECG)
Practice with the ECG!
Artificial pacemakers

Pacemakers
Hypertension and thrombosis

Research and create a poster on hypertension and thrombosis

The poster should include...

Definition, cause, consequences, incidence rate, outcome, diagnosis, who is affected (including gender, age, activity, genotypes)
Complete DBQ on pg. 692-693