Cement

- Polymer powder (two-thirds)
  - methylmethacrylate/styrene co-polymer (Simplex) or methylmethacrylate/methacrylate co-polymer (Palacos)
  - radio-opacifier of barium sulphate (Simplex) or zirconium dioxide (Palacos)
  - initiator is benzoylperoxide

- Monomer liquid (one-third)
  - MMA
  - Activator – dimethylparatoluidine
  - Inhibitor – hydroquinone
  - Antibiotics – gentamicin (Palacos), tobramycin, erythromycin / colistin (Simplex)
  - Custom antibiotics – usually 3-4g of a heat-stable antibiotic available in powder form can be added to the polymer powder and hand mixed.

- Polymerisation is exothermic (52 kJ per mole of MMA), but temperatures do not exceed that to cause irreversible damage to adjacent bone in vivo
  - Set time reduced for each degree Celcius the ambient temperature rises
  - Usually 8 – 10 minutes
  - At set time, 95% of monomer has polymerised
  - 99.5 polymerisation at 3-4 weeks – thus explains why properties of creep, stress relaxation and flexibility change during 1st four weeks
  - 7% shrinkage (based on 2:1 ratio of polymer:monomer) – this is reduced to 5% by vacuum mixing which reduces porosities
  - Viscosity-time curves are usually S-shape with the low-gradient portion representing the working time, where cement can be moulded

- ISO standard for cement focuses on minimum compression strength (70MPa) and bending modulus (1800MPa) – however failure modality is rarely in compression or bending!

- Tension and shear strength is lower, and thus it is important for cement to interdigitate with cancellous bone in order to generate compression

- Creep and stress relaxation can occur at body temperatures as PMMA is an amorphous polymer with long-chain molecules entangled – held by secondary bonds
  - These weaken as temperature rises allowing chain to slide to increase strain under constant load, or reduce stress when under constant deformation

- Vacuum mixing of cement reduces porosity from air or monomer bubbles. However porosity may or may not affect fatigue strength in vivo.
  - In vitro tests suggest porosity weakens fatigue strength, but do not account for stress relaxation or creep within the material which protect against fatigue failure in vivo (and in particular with force-closed prostheses)
  - Another benefit is it avoids operator exposure to monomer fumes which some consider unpleasant.
<table>
<thead>
<tr>
<th>Simplex</th>
<th>Palacos</th>
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<tbody>
<tr>
<td>Powder: methylmethacrylate/styrene co-polymer</td>
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<tr>
<td>Radio-opacifier: barium</td>
<td>Radio-opacifier: zirconium</td>
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<tr>
<td>Pre-loaded antibiotics: erythromycin/colistin or tobramycin</td>
<td>Pre-loaded antibiotics: gentamicin</td>
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<tr>
<td>Working time: between 4 and 7 ½ minutes</td>
<td>Working time: between 1½ and 5 minutes</td>
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<tr>
<td>Set time: 10½ minutes</td>
<td>Set time: 8 minutes</td>
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