curcumin (Gong et al. 2013) and local anaesthetics, for example, lidocaine (Negi et al. 2014). Distinct from these examples, there are also numerous reports of hydrogels being applied transdermally for the purposes of systemic delivery. For example, chitosan hydrogels have been used for delivery of glimepiride (Ammar et al. 2008) the active S-enantiomer of racemic propranolol (Suedee et al. 2008). Liu et al. (2014) designed a hydrogel formulation of tolterodine for the treatment of overactive bladder, achieving sustained release over 24 h and greater bioavailability than oral administration of tablets in rats. Considering marketed products, IONSYS®, a fentanyl iontophoretic transdermal system, has recently been re-launched, indicated for the short-term management of acute postoperative pain in hospital settings (Scott 2016). The fentanyl in this patch is contained within a hydrogel reservoir, the electrical current essential for driving the fentanyl across the skin upon activation of the system. However, despite the examples discussed, the use of a hydrogel formulation alone is generally not sufficient to guarantee transdermal penetration of the active ingredient. The technologies showing the greatest promise in transdermal delivery are those that are designed to temporarily manipulate the skin barrier, increasing permeation by disruption of the outermost layer of skin, the *stratum corneum* (Prausnitz and Langer 2008). Microneedles are an example of this, mechanically creating pores in the *stratum corneum* and physically bypassing the principal skin barrier. A microneedle array is a collection of numerous micron-sized projections (50–900 μm), amassed on a baseplate (Fig. 1). When applied to the skin, the tiny needles puncture the *stratum corneum*, forming aqueous conduits for diffusion to the dermal microcirculation. Microneedle drug delivery can occur via a variety of mechanisms including drug-coated microneedles, soluble microneedles with drug incorporated or infusion through hollow microneedles (Tuan-Mahmood et

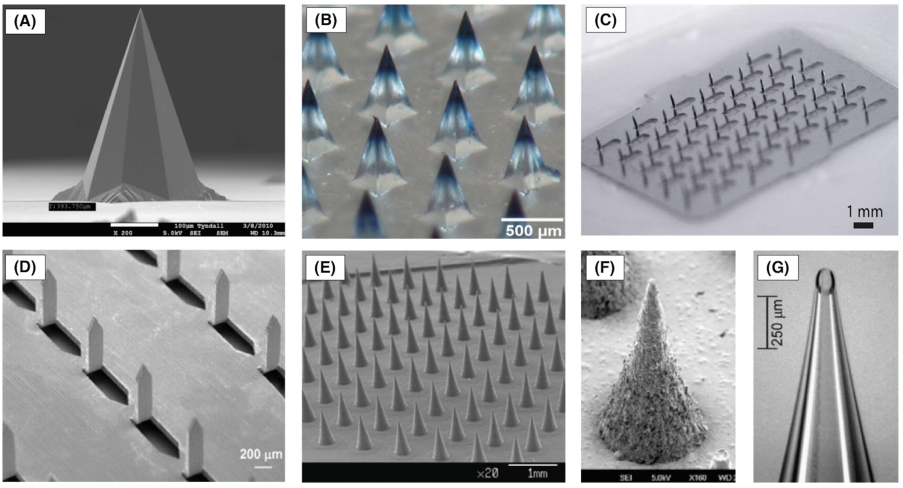

Fig. 1. Microscope images of microneedles used for transdermal drug delivery. (A) Silicon microneedle of height 400 μm (O'Mahony 2014). (B) Dissolving microneedles prepared from sucrose and PVA (Edens et al. 2015). (C) Array of 100 stainless steel microneedles of height 750 μm (Norman et al. 2014). (D) Out-of-plane stainless steel microneedles of height 700 μm (Gill and Prausnitz 2007). (E) Dissolving microneedle array (needle height 800 μm) prepared from poly(vinyl pyrrolidone) (Wang et al. 2015). (F) Single polymeric microneedle of height 600 μm (Donnelly et al. 2010). (G) Hollow glass microneedle (Martanto et al. 2006).