Like holography, ptychography is a method of measuring the phase and amplitude of a scattered wavefield [1,2]. Unlike holography, it does not require a reference wave – the object itself acts as its own diffracting reference. An area of illumination (which can be formed either by a simple aperture upstream of the object, or by a lens) is moved over the object while a series of either Fraunhofer or Fresnel diffraction patterns are recorded. Each diffraction pattern is obtained from an area of the specimen which overlaps with another area of specimen previously illuminated, thus introducing a large degree of redundancy in the data: this is used to solve the phase problem (i.e. to calculate the phase of the diffraction patterns which can only be measured in intensity). This roundabout lensless method creates aberration-free very high contrast absolute phase images (less than 0.02 radian sensitivity) at a resolution determined by the effective numerical aperture dictated by the angle subtended by the detector at the object plane. Because it does not rely on any reference beam, or indeed any form of interferometry (including lens image formation) the technique is extraordinarily robust to vibration. Unlike standard metrology techniques, in reflection mode it can be used to measure step sizes of less than 1nm while the apparatus in mounted on a conventional (not an optical) bench. In transmission mode, through-focal series can be obtained after the experiment has been performed, because, again like holography, the whole wavefront has been recovered in modulus and phase.

From left in the figures below, we firstly see a typical diffraction pattern from a biological specimen: this is the data used for the reconstruction. In the second image, we see 549 adenocarcinomic human alveolar basal epithelial cells (field of view 350μm): note the very high contrast. Right: a very strong and extensive phase object – the phase map from a toric contact lens in liquid (field of view 14 mm) – optical thickness can be measured to 0.1μm.