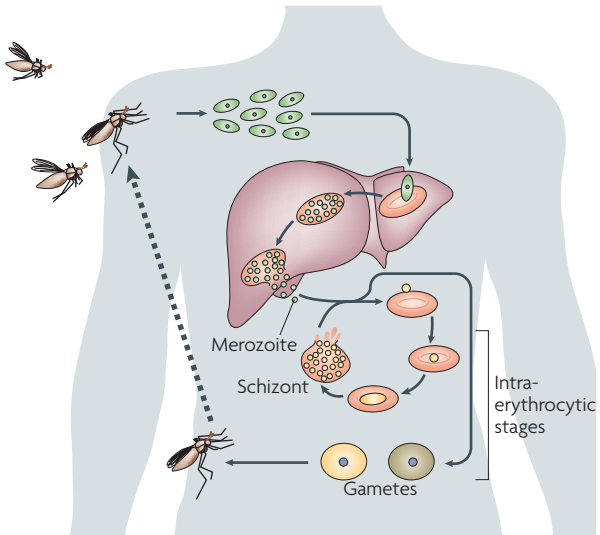
MALARIA

Picking *Plasmodium falciparum* apart

Compartmentalization of proteins into subcellular organelles is a widespread process that enables the regulation of many cellular functions. In the malaria parasite *Plasmodium falciparum*, compartmentalization is well established, but not fully understood. Using imaging techniques, two groups now provide insight into the organelle structures that are present during different stages of the parasite's life cycle. Singh *et al.* identify a novel invasion-related organelle — the mononeme — that is present during the merozoite stage, and Hanssen *et al.* take a closer look at the structure of Maurer's cleft organelles, which are present during the intra-erythrocytic stages.



The life cycle of *Plasmodium falciparum*. Image modified from *Nature Reviews Microbiology* **3**, 893–899 © (2005) Macmillan Publishers Ltd.

During the merozoite stage (see the figure), *P. falciparum* possesses various secretory organelles, such as rhoptries and micronemes. Evidence suggests that the compartmentalization of proteins into these organelles ensures that invasion-related proteins are properly targeted (both spatially and temporally) for invasion, thereby ensuring that these proteins do not adversely affect the parasite itself.

One such invasion-related protein is the protease rhomboid 1 (ROM1) — ROM1 cleaves, among other substrates, *P. falciparum* apical membrane antigen 1 (AMA1), a protein that is also crucial for invasion. Suspecting that ROM1 might be sequestered away from AMA1, Singh *et al.* stained ROM1 and analysed cells using immunoconfocal microscopy. Indeed, in merozoites ROM1 localized exclusively to a novel thread-like organelle — which the authors called the mononeme (from the Greek 'mono', meaning single, and 'neme', meaning thread) — and was thereby effectively separated from AMA1 until its protease activity was required.

Following the invasion of erythrocytes by merozoites, *P. falciparum* enters the intra-erythrocytic stages, which are responsible for the clinical pathology of malaria. Malaria virulence is, in part, attributable to adhesion proteins that are inserted into the host cell membrane, but as erythrocytes lack organelles for protein trafficking it is unclear how the parasite effects the transportation of these proteins. Maurer's cleft organelles, which are membranous structures that are formed by *P. falciparum* in the erythrocyte cytoplasm, are thought to be important for this trafficking.

Using electron tomography, Hanssen *et al.* revealed some novel structural features of Maurer's clefts. For example, they showed that these organelles are flattened structures that are connected to the erythrocyte membrane by stalk-like regions. Furthermore, although Maurer's clefts appear to be physically connected to the erythrocyte membrane and the parasitophorous vacuole membrane (which separates the parasite from the erythrocyte cytoplasm), photobleaching experiments revealed that there is no lipid continuum between these structures.

Not only do these studies provide insights into erythrocyte invasion by merozoites and the organization of *P. falciparum* during the intra-erythrocytic stages, they also reveal the power of imaging techniques.

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ORIGINAL RESEARCH PAPERS Singh, *et al.* Mononeme: a new secretory organelle in *Plasmodium falciparum* merozoites identified by localization of rhomboid-1 protease. *Proc. Natl Acad. Sci. USA* **104**, 20043–20048 (2007) | Hanssen, E. *et al.* Electron tomography of the Maurer's cleft organelles of *Plasmodium falciparum*-infected erythrocytes reveals novel structural features. *Mol. Microbiol.* 7 Dec 2007 (doi: 10.1111/j.1365-2958.2007.06063.x)