Uniform nomenclature for the mitochondrial contact site and cristae organizing system

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The mitochondrial inner membrane contains a large protein complex that functions in inner membrane organization and formation of membrane contact sites. The complex was variably named the mitochondrial contact site complex, mitochondrial inner membrane organizing system, mitochondrial organizing structure, or Mitofilin/Fc1 complex. To facilitate future studies, we propose to unify the nomenclature and term the complex “mitochondrial contact site and cristae organizing system” and its subunits Mic10 to Mic60.

Mitochondria possess two membranes of different architecture and function (Palade, 1952; Hackenbrock, 1968). Both membranes work together for essential shared functions, such as protein import (Schatz, 1996; Neupert and Herrmann, 2007; Chacinska et al., 2009). The outer membrane harbors machinery that controls the shape of the organelle and is crucial for the communication of mitochondria with the rest of the cell. The inner membrane harbors the complexes of the respiratory chain, the F1F0-ATP synthase, numerous metabolite carriers, and enzymes of mitochondrial metabolism. It consists of two domains: the inner boundary membrane, which is adjacent to the outer membrane, and invaginations of different shape, termed cristae (Werner and Neupert, 1972; Frey and Mannella, 2000; Hoppins et al., 2007; Pellegrini and Scorrano, 2007; Zick et al., 2009; Davies et al., 2011). Tubular openings, termed cristae junctions (Perkins et al., 1997), connect inner boundary membrane and cristae membranes (Fig. 1, A and B). Respiratory chain complexes and the F1F0-ATP synthase are preferentially located in the cristae membranes, whereas preprotein translocases are enriched in the inner boundary membrane (Vogel et al., 2006; Wurm and Jakobs, 2006; Davies et al., 2011). Contact sites
lost cristae junctions and contain large internal membrane stacks, the respiratory activity is reduced, and mitochondrial DNA nucleoids are altered (Fig. 1 B; John et al., 2005; Hess et al., 2009; Rabl et al., 2009; Mun et al., 2010; Harner et al., 2011; Head et al., 2011; Hoppins et al., 2011; von der Malsburg et al., 2011; Alkhaja et al., 2012; Itoh et al., 2013). It has been reported that the complex interacts with a variety of outer membrane proteins, such as channel proteins and components of the protein translocases and mitochondrial fusion machines, and defects impair the biogenesis of mitochondrial proteins (Xie et al., 2007; Darshi et al., 2011; Hoppins et al., 2011; von der Malsburg et al., 2011; Alkhaja et al., 2012; An et al., 2012; Bohnert et al., 2012; Körner et al., 2012; Ott et al., 2012; Zerbes et al., 2012; Jans et al., 2013; Weber et al., 2013). The MICOS/MINOS/MitOS/Mitofilin/Fcj1 complex thus plays crucial roles in mitochondrial architecture, dynamics, and biogenesis. However, communication of results in this rapidly developing field has been complicated by several different nomenclatures used for the complex as well as for its subunits (Table 1). To rectify this situation, all authors of this article have agreed on a new uniform nomenclature with the following guidelines. (a) The complex will be called “mitochondrial contact site and cristae organizing system” (MICOS). The protein subunits of MICOS are named Mic10 to Mic60 as listed in Table 1. (b) The names, including the numbers shown in Table 1, will be used in all organisms, e.g., Mitofilin/Fcj1 will be named Mic60 in any organism. In case the name MicX has been given to another gene/protein in an organism or a database requires a longer name, the...
name MiccX will be used in this organism, but the number will not be changed. The use of capital and small letters as well as of italics will follow species-specific conventions, e.g., in budding yeast (Saccharomyces cerevisiae), Mic60 will be used for the protein, and MIC60 will be used for the gene. (c) The current names of MICOS genes and proteins in databases will be renamed according to the uniform nomenclature. This includes the names of mutants when they contain the name of a MICOS gene or protein, e.g., *fcj1Δ* mutant cells will be renamed to *mic60Δ* mutant cells. (d) In case several isoforms of a MICOS subunit are present in an organism, this will usually be indicated by -1, -2, etc. (e) In case new subunits of MICOS will be identified, they will be named MicY. The number Y will be the molecular mass of the identified mature protein in kilodaltons. The same number will be used for orthologues identified in other organisms. (f) The names Mic14, Mic17, and Mic23 (mitochondrial intermembrane space cysteine motif proteins) that are currently used for three non-MICOS yeast proteins (Gabriel et al., 2007; Vögtle et al., 2012) will be changed to Mix14, Mix17, and Mix23 (mitochondrial intermembrane space CX,C motif proteins) in the *Saccharomyces* Genome Database, and the new nomenclature will be used for orthologues identified in other organisms.

The MICOS complex is of central importance for the maintenance of mitochondrial inner membrane architecture and the formation of contact sites between outer and inner membranes and thus is involved in the regulation of mitochondrial dynamics, biogenesis, and inheritance. We expect that the uniform nomenclature will facilitate future studies on mitochondrial membrane architecture and dynamics.

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### Table 1. New nomenclature of MICOS

<table>
<thead>
<tr>
<th>Complex</th>
<th>Standard name</th>
<th>Former names</th>
<th>Yeast ORF</th>
<th>References</th>
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<tr>
<td>MICOS</td>
<td>MINOS, MitOS, MIB, Mitofilin complex, and Fcj1 complex</td>
<td>Mics10, Mio10, Ms1, and MINOS1</td>
<td>YCL057C-A</td>
<td>Harner et al., 2011; Hoppins et al., 2011; von der Malsburg et al., 2011; Alkhaja et al., 2012; An et al., 2012; Bohnert et al., 2012; Ott et al., 2012; Jans et al., 2013; Weber et al., 2013</td>
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Subunits

| Mic10 | Mics10, Mio10, Ms1, and MINOS1 | YCL057C-A | Harner et al., 2011; Hoppins et al., 2011; von der Malsburg et al., 2011; Alkhaja et al., 2012; Itoh et al., 2013; Jans et al., 2013; Varabyova et al., 2013 |
| Mic12 | Aim5, fmp51, and Msc12 | YBR262C | Hess et al., 2009; Harner et al., 2011; Hoppins et al., 2011; von der Malsburg et al., 2011; Varabyova et al., 2013 |
| Mic19 | Aim13, Msc19, CHCH3, CHCHD3, and MINOS3 | YFR011C | Xie et al., 2007; Hess et al., 2009; Harner et al., 2011; Head et al., 2011; Alkhaja et al., 2012; Ott et al., 2012; Jans et al., 2013; Varabyova et al., 2013 |
| Mic25 (metazoan Mic19 homologue) | CHCHD6 and CHCM1 | YGR235C | Harner et al., 2011; Hoppins et al., 2011; von der Malsburg et al., 2011; Alkhaja et al., 2012; Itoh et al., 2013; An et al., 2012 |
| Mic26 | Msc29, Mio27, and Ms2 | YCL058C | Hass et al., 2009; Harner et al., 2011; Head et al., 2011; Hoppins et al., 2011; von der Malsburg et al., 2011; Weber et al., 2013 |
| Mic27 | Aim27, Msc27, APOOL, and MOMA-1 | YNL100W | Hess et al., 2009; Harner et al., 2011; Head et al., 2011; Hoppins et al., 2011; von der Malsburg et al., 2011; Alkhaja et al., 2012; Itoh et al., 2013; Varabyova et al., 2013 |
| Mic60 | Fcj1, Aim28, Fmp13, Mitofilin, HMP, IMMAT, and MINOS2 | YKR016W | Itoh et al., 1994; Odgren et al., 1996; Gieffers et al., 1997; John et al., 2005; Wang et al., 2008; Rabl et al., 2009; Rossi et al., 2009; Mun et al., 2010; Park et al., 2010; Körner et al., 2012; Zerbes et al., 2012; Itoh et al., 2013; Varabyova et al., 2013 |

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Varabyova et al., 2013

Körner et al., 2013; Jans et al., 2013; Zerbes et al., 2012; Itoh et al., 2013; Varabyova et al., 2013

Weber et al., 2013

Xie et al., 2007; Rabl et al., 2009; Darshi et al., 2011; Harner et al., 2011; Hoppins et al., 2011; von der Malsburg et al., 2011; Alkhaja et al., 2012; An et al., 2012; Bohnert et al., 2012; Ott et al., 2012; Jans et al., 2013; Weber et al., 2013

YCL057C-A

YBR262C

YFR011C

YGR235C

YCL058C

YNL100W

YKR016W

APOOL, apolipoprotein O–like; HMP, heart muscle protein; IMMT, inner mitochondrial membrane protein; MIB, mitochondrial intermembrane space bridging.


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