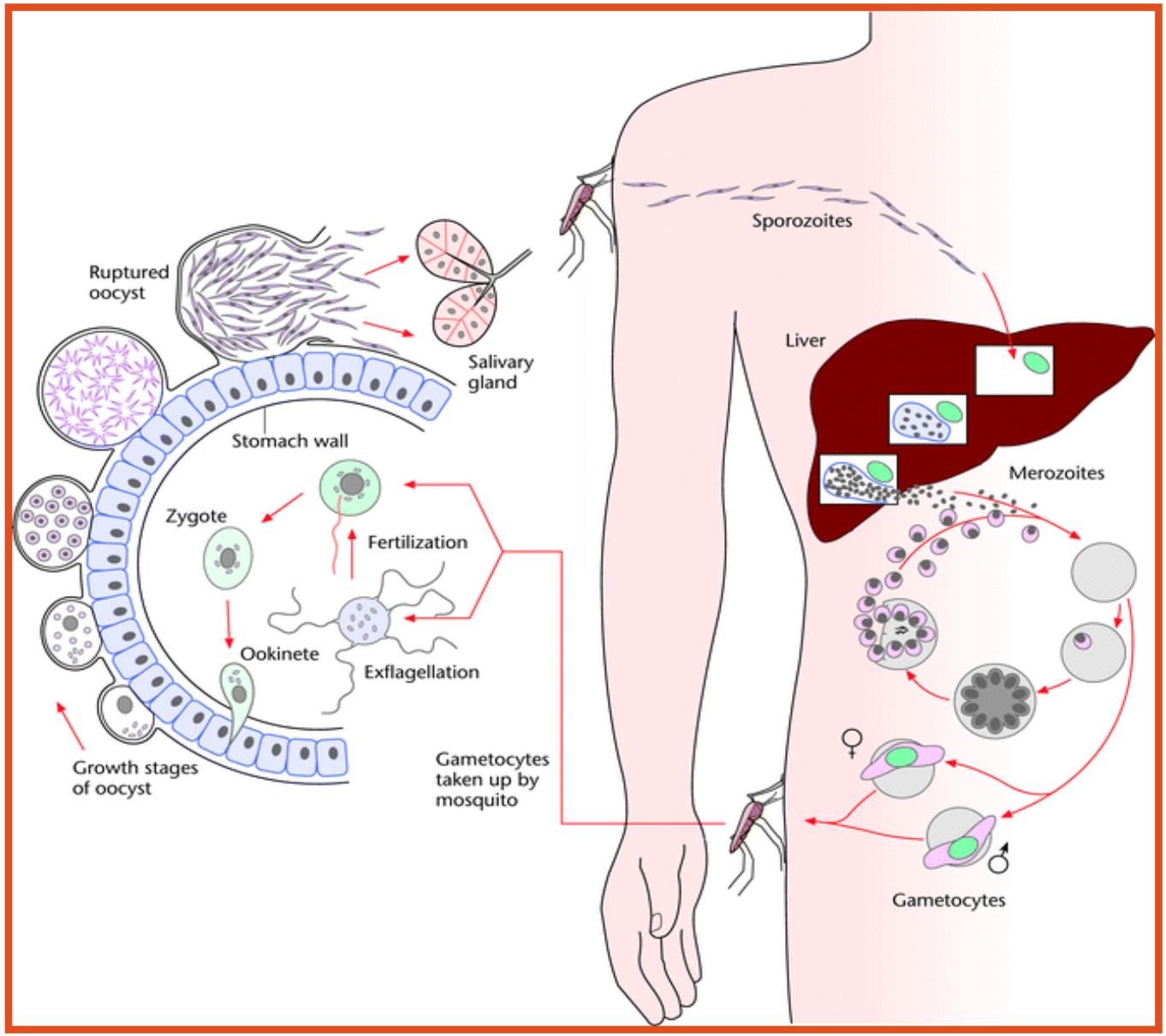
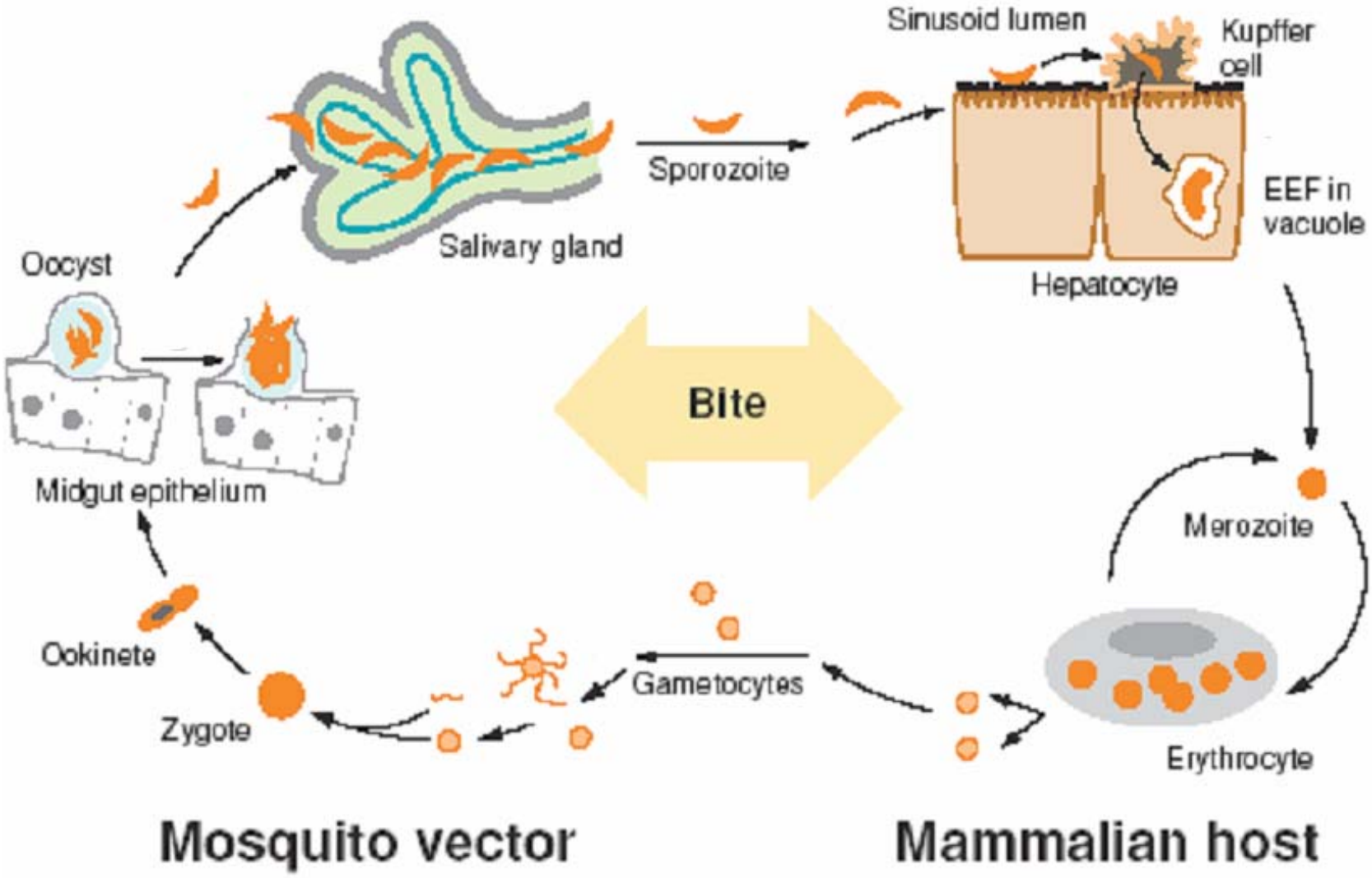
Sporozoite - host interactions

Plasmodium falciparum life cycle



http://www.insp.mx/xcongreso/ponencias/miercoles/carmen_rodriguez.ppt

Plasmodium falciparum life cycle



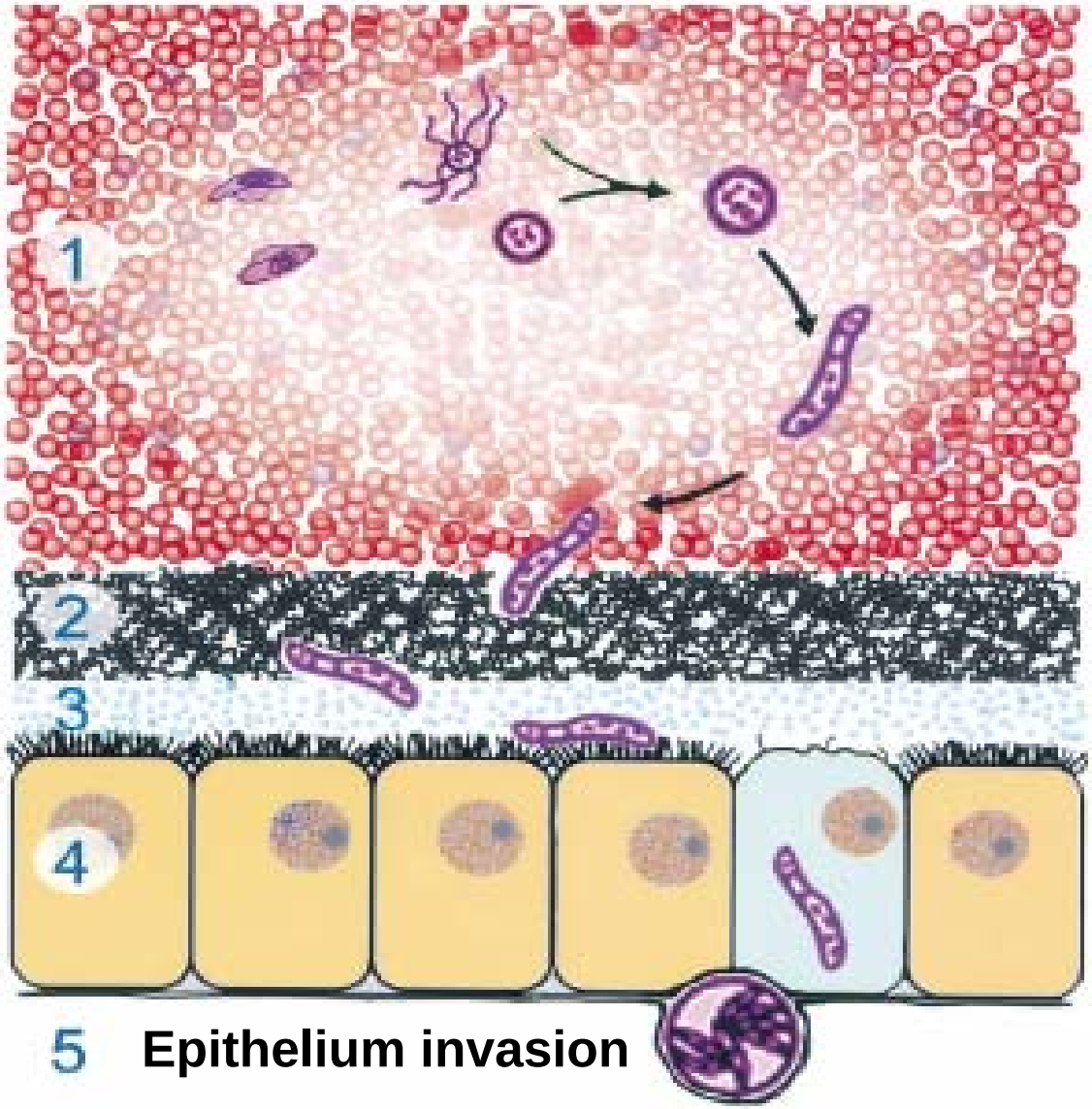
Kappe Stefan H. I. *et al* 2004. **Annu. Rev. Cell Dev. Biol**. 20: 29

Gametocyte, zygote, ookinete and oocyst

Bloodmeal bolus

Peritrophic matrix

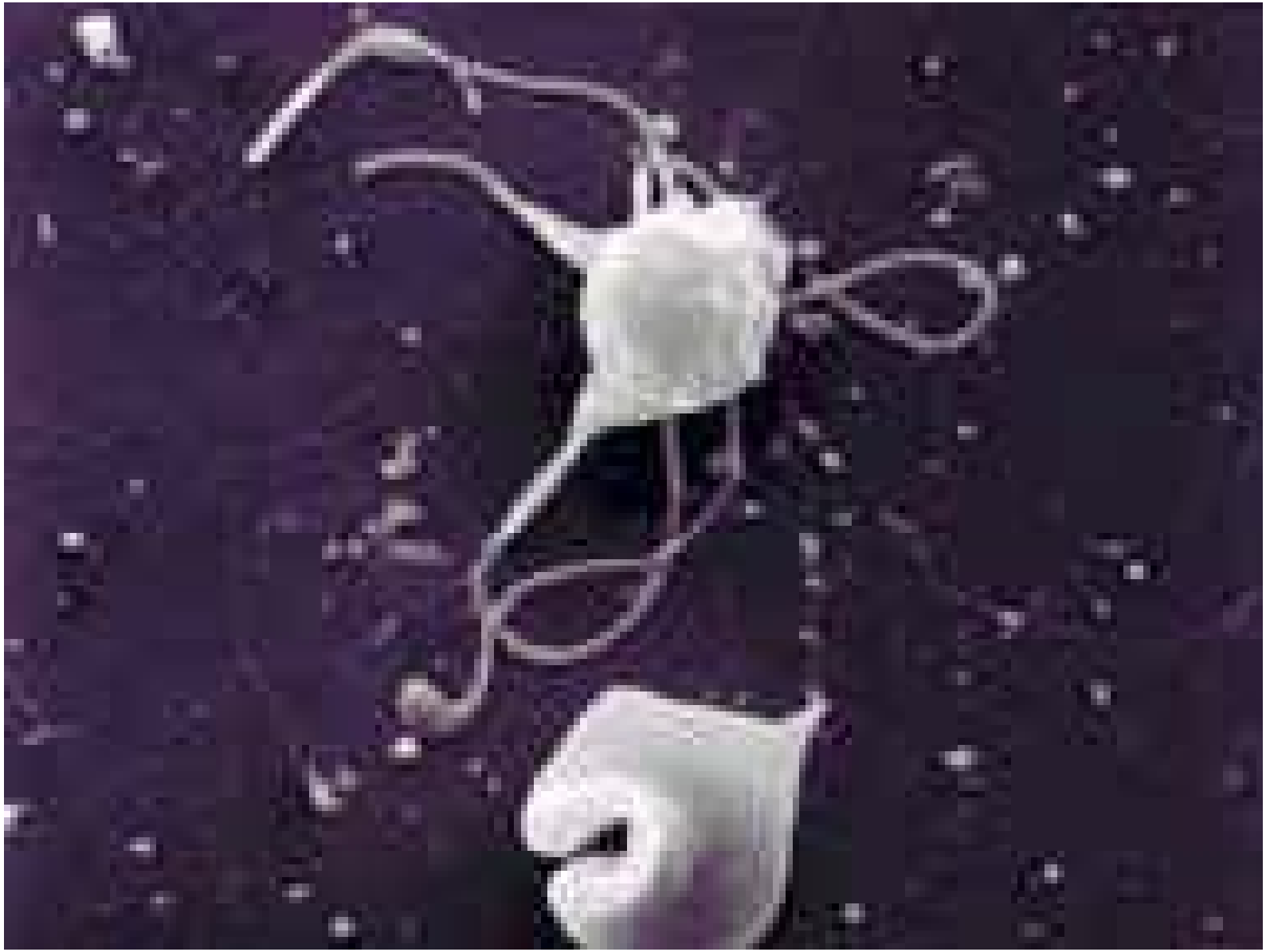
Microvillar network



Epithelial cell

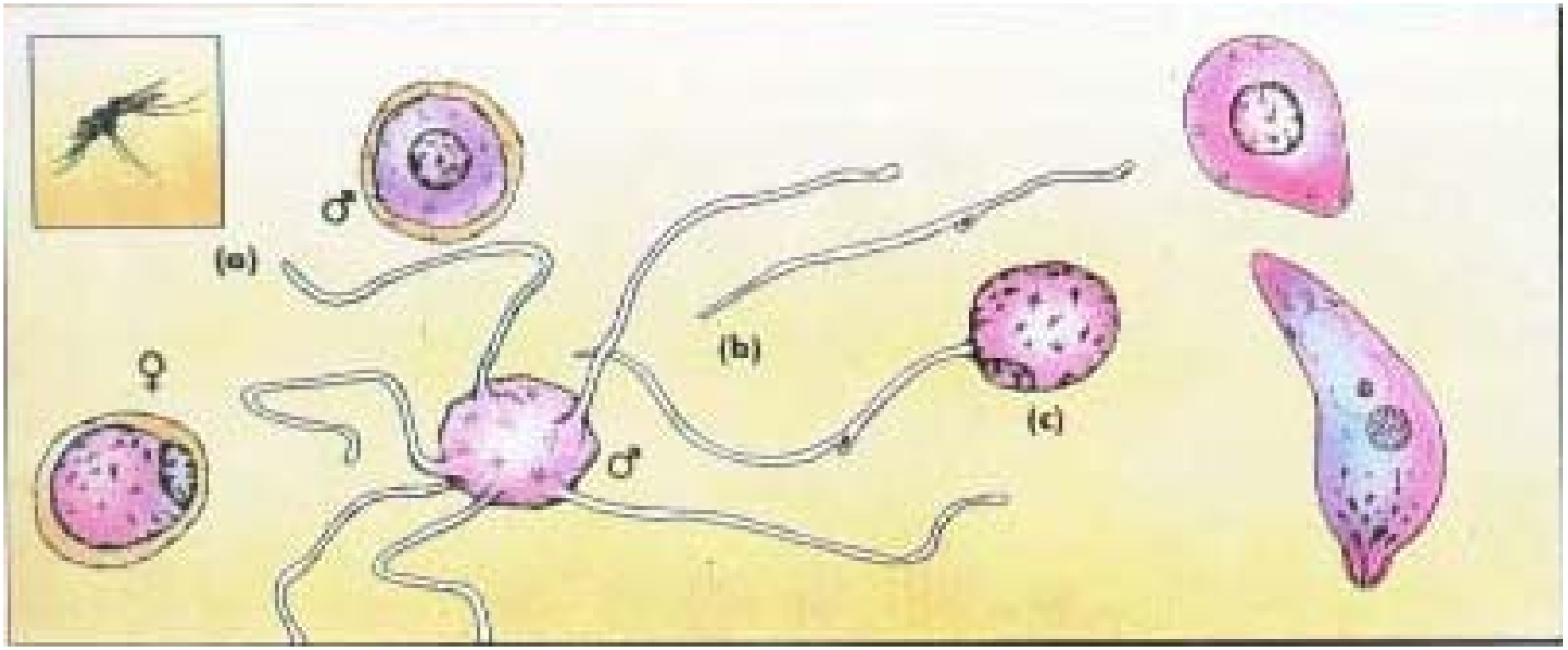
http://www.insp.mx/xcongreso/ponencias/miercoles/carmen_rodriguez.ppt

Plasmodium gametocyte



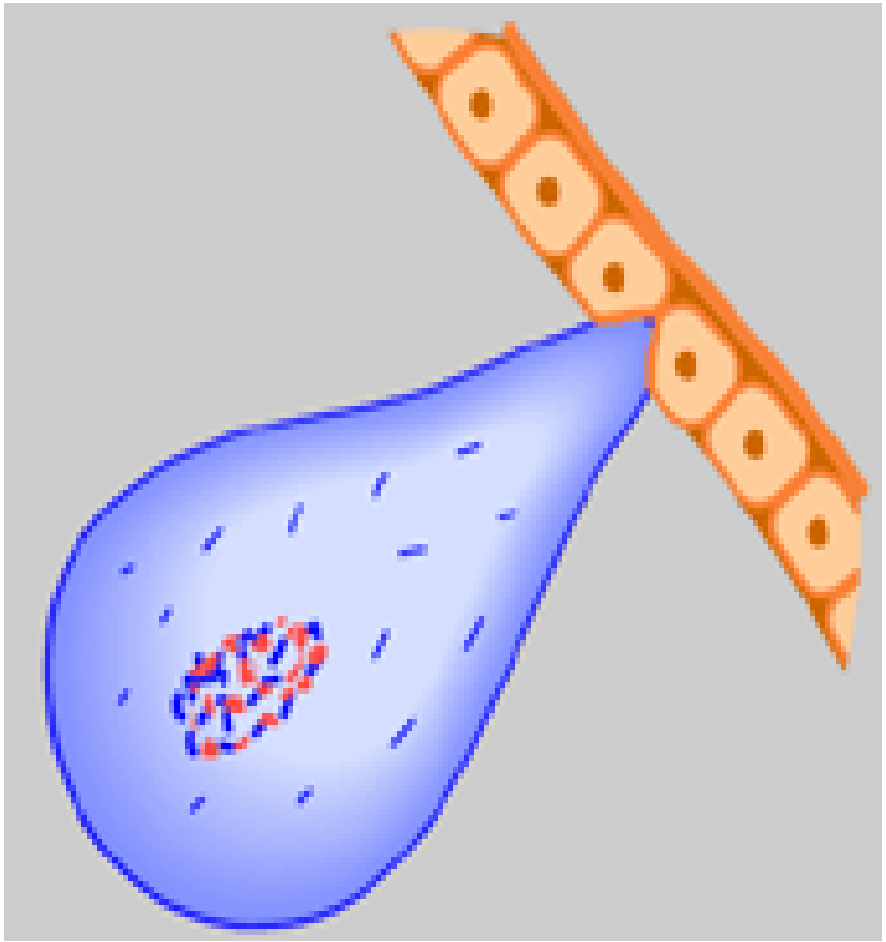
www.bio.ic.ac.uk/researh/res/sinden.htm

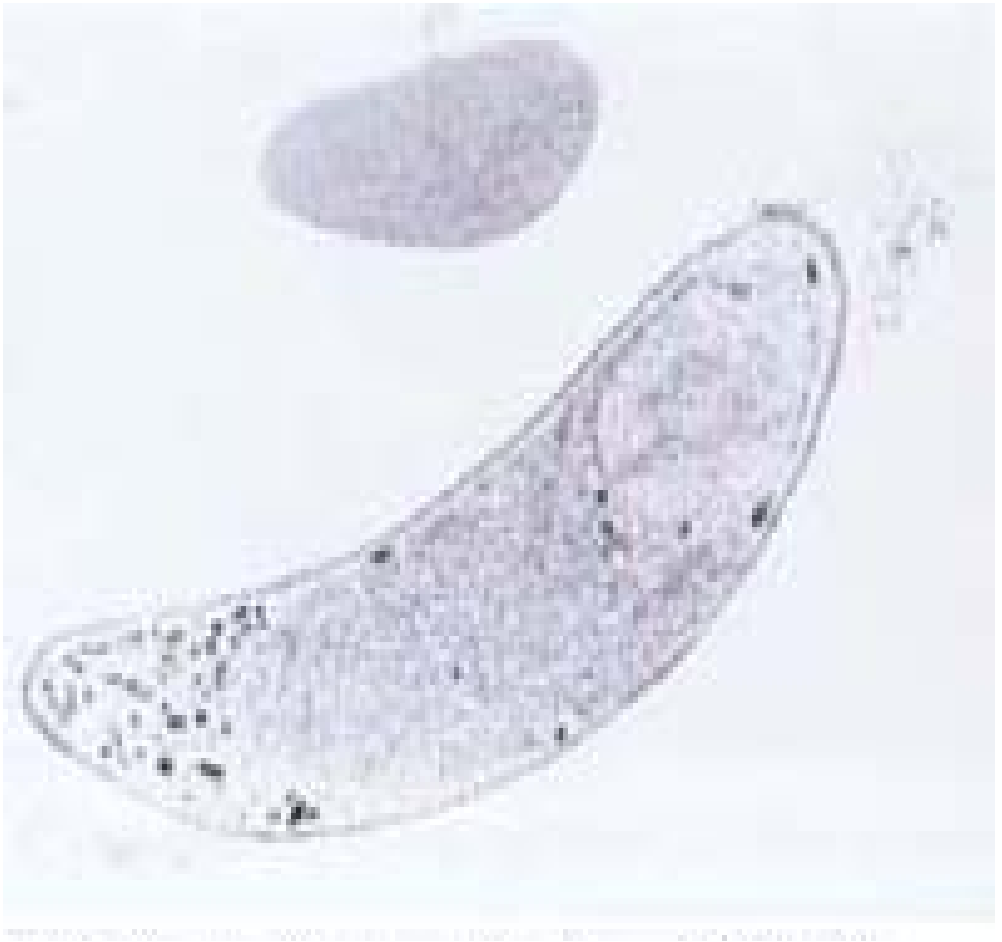
Zygote formation



http://www.brown.edu/Courses/Bio_160/Projects1999/malaria/ldpg.html#BM40

Ookinete

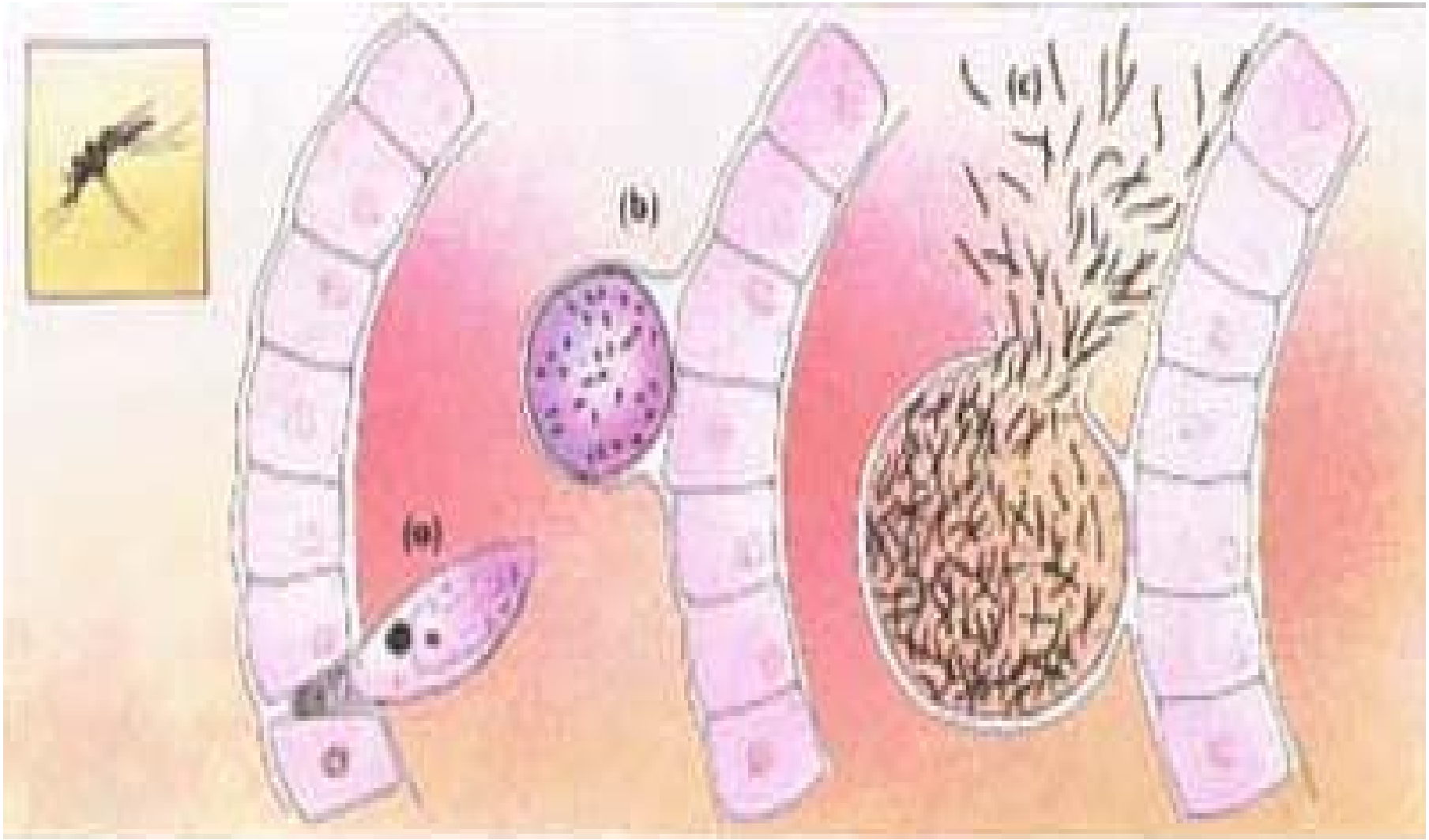




http://www.brown.edu/Courses/Bio_160/Projects1999/malaria/ldpg.html#BM40

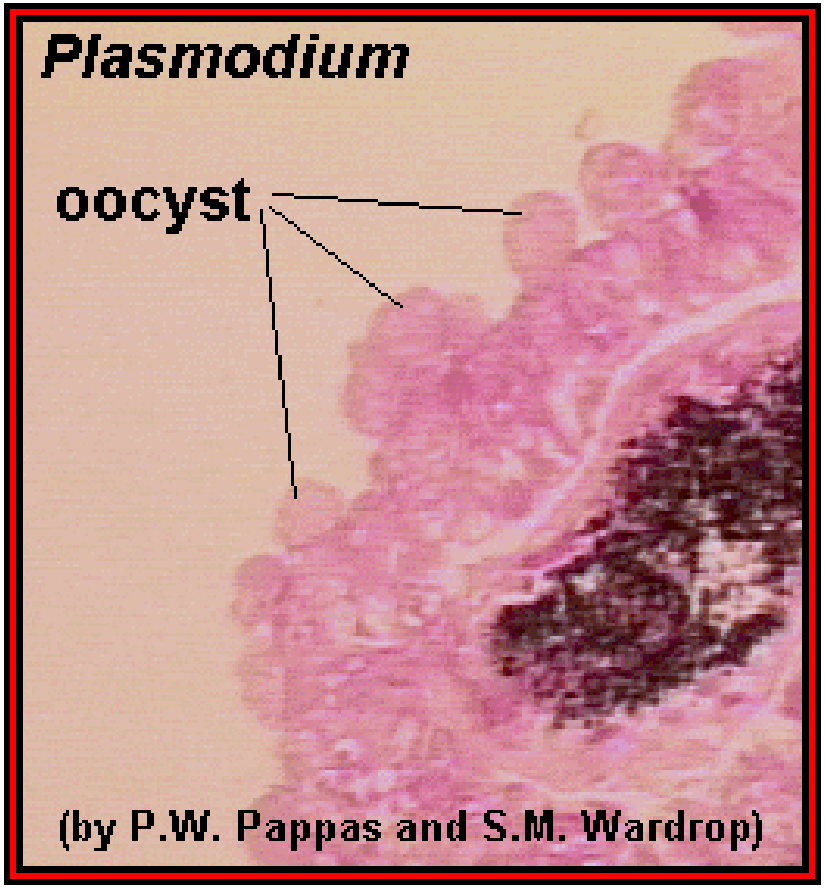
Knell A.J. 1987 **Am J Trop Med Hyg**. :37:412

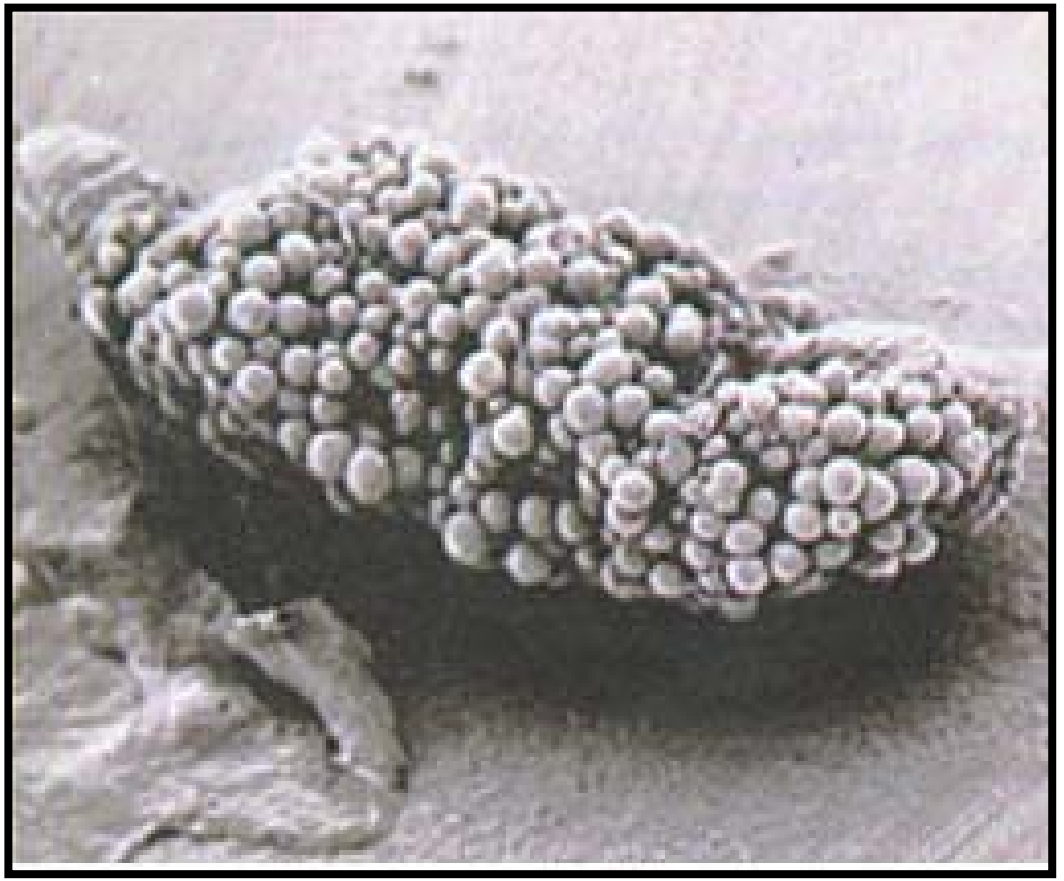
Multiplication in the mosquito



http://www.brown.edu/Courses/Bio_160/Projects1999/malaria/ldpg.html#BM40

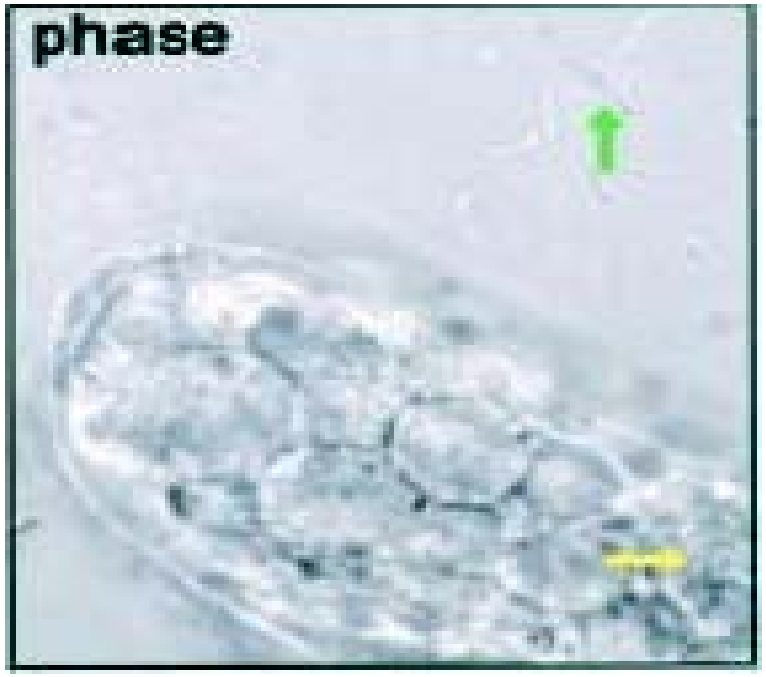
Plasmodium oocysts on the surface of a mosquito gut

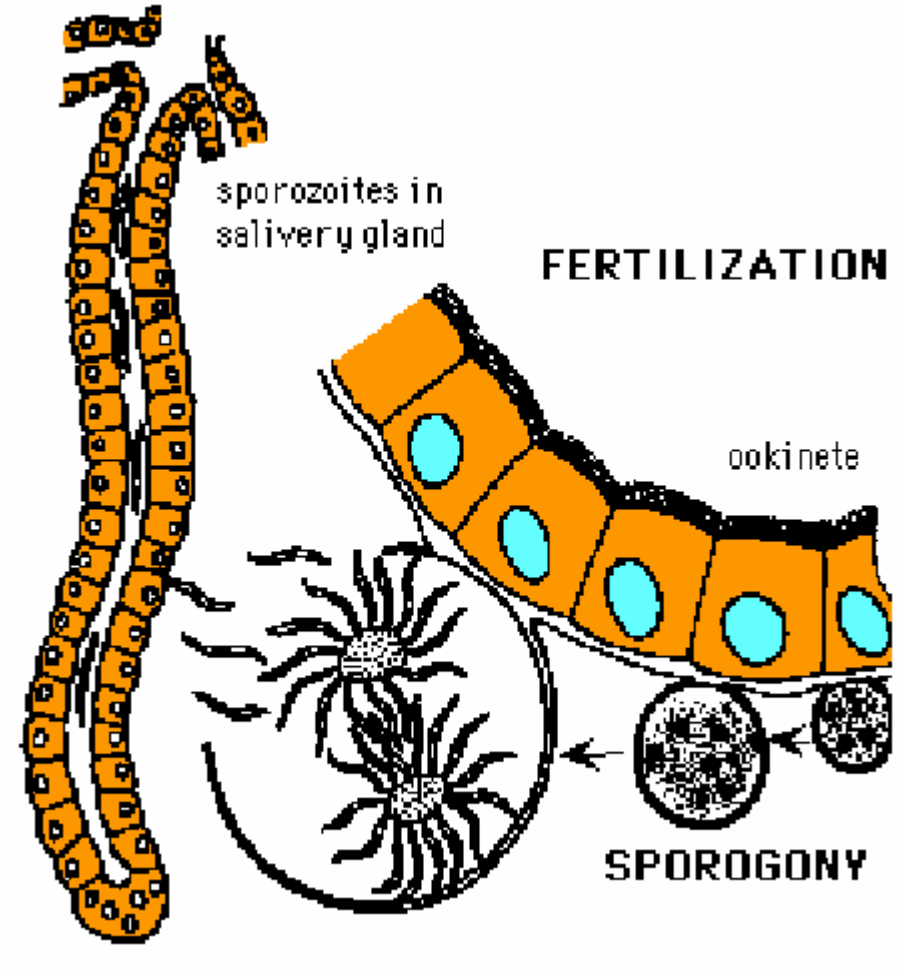




http://www.brown.edu/Courses/Bio_160/Projects1999/malaria/ldpg.html#BM40

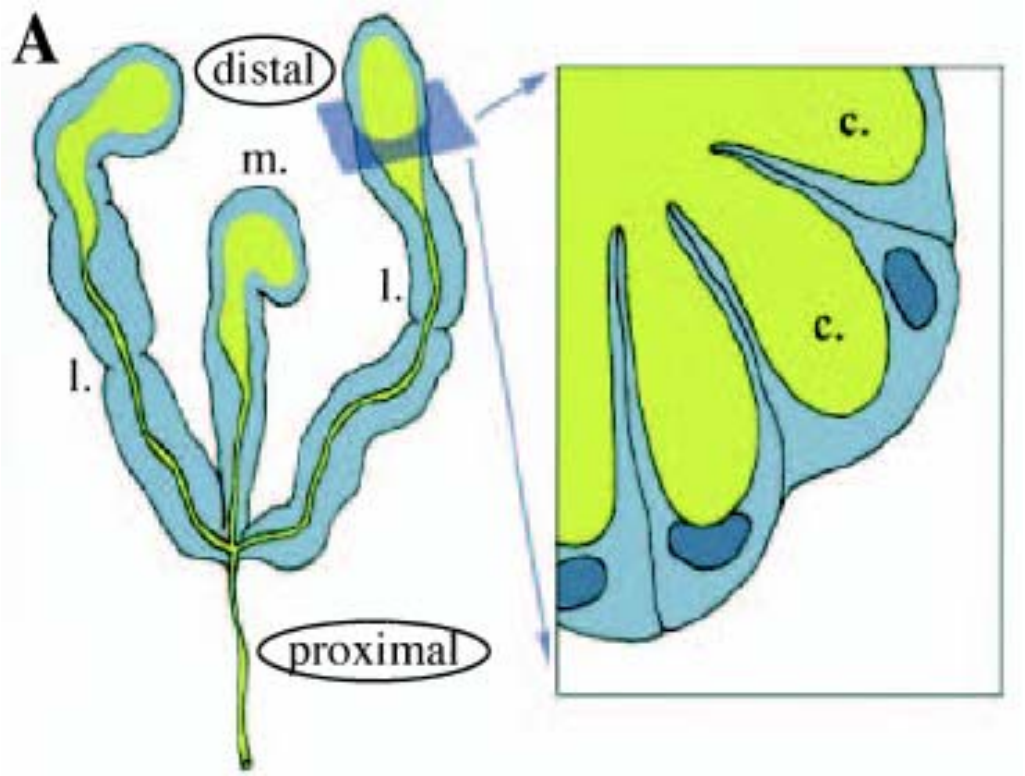
Oocyst ruptures to liberate sporozoites which penetrate the salivary gland

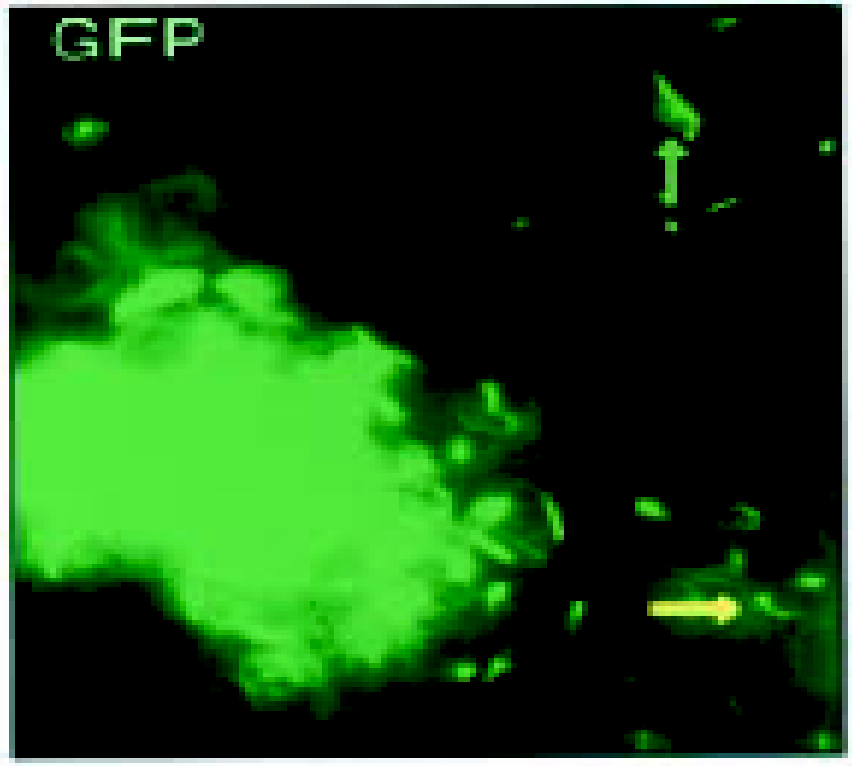




Matuschewski K. *et al*. 2002 **J Biol Chem** 277: 41948

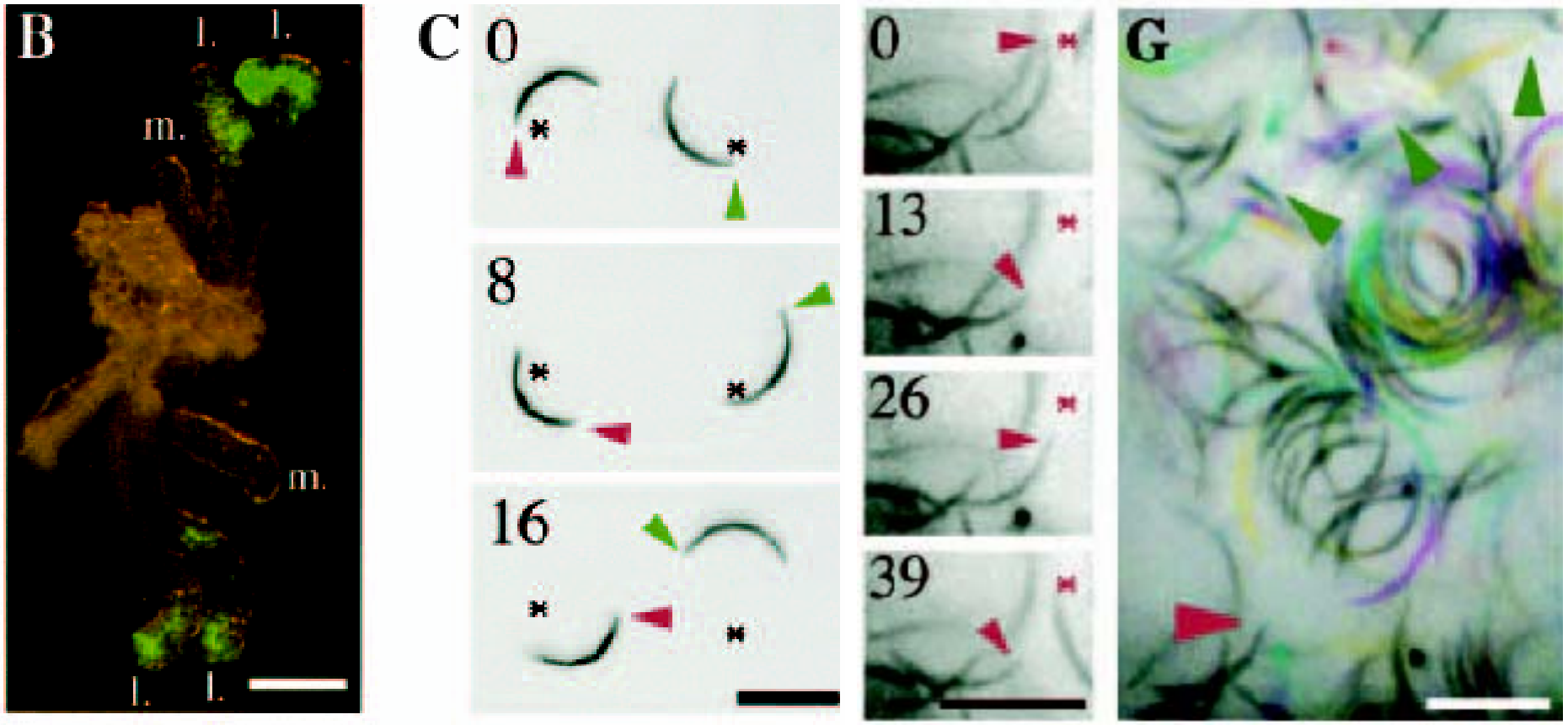
Sporozoites within the salivary gland





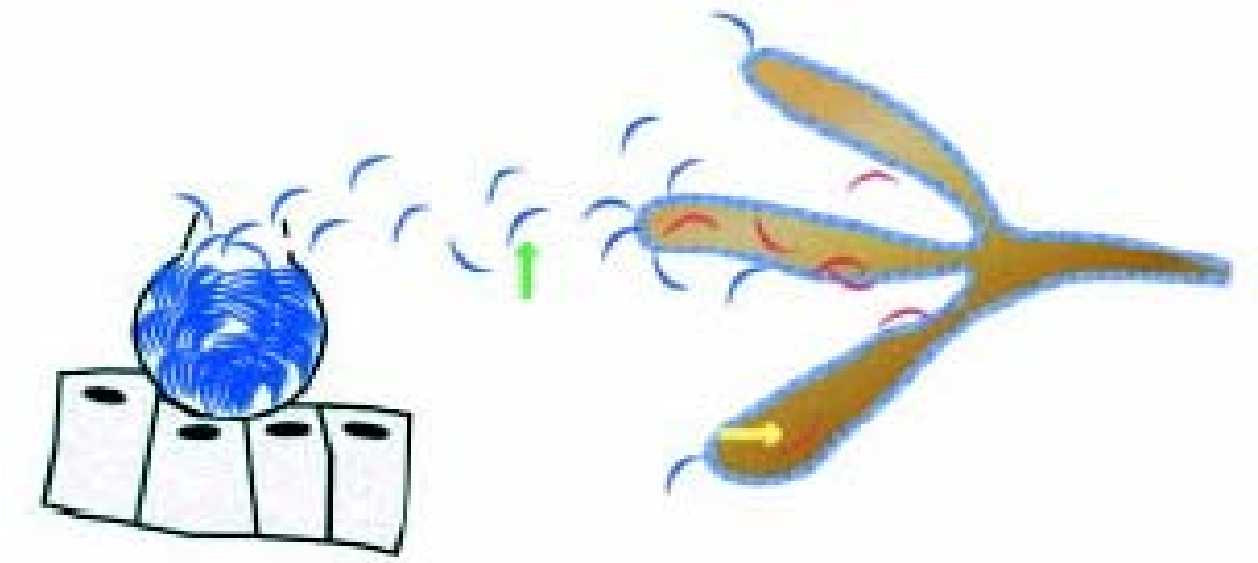
Frischknecht F, et al, 2004, **Cell Microbiol**., Matuschewski K. *et al*. 2002 **J Biol Chem** 277: 41948

Sporozoite motility within the salivary gland



Frischknecht F et al. 2004 **Cellular Microbilogy** 6:687

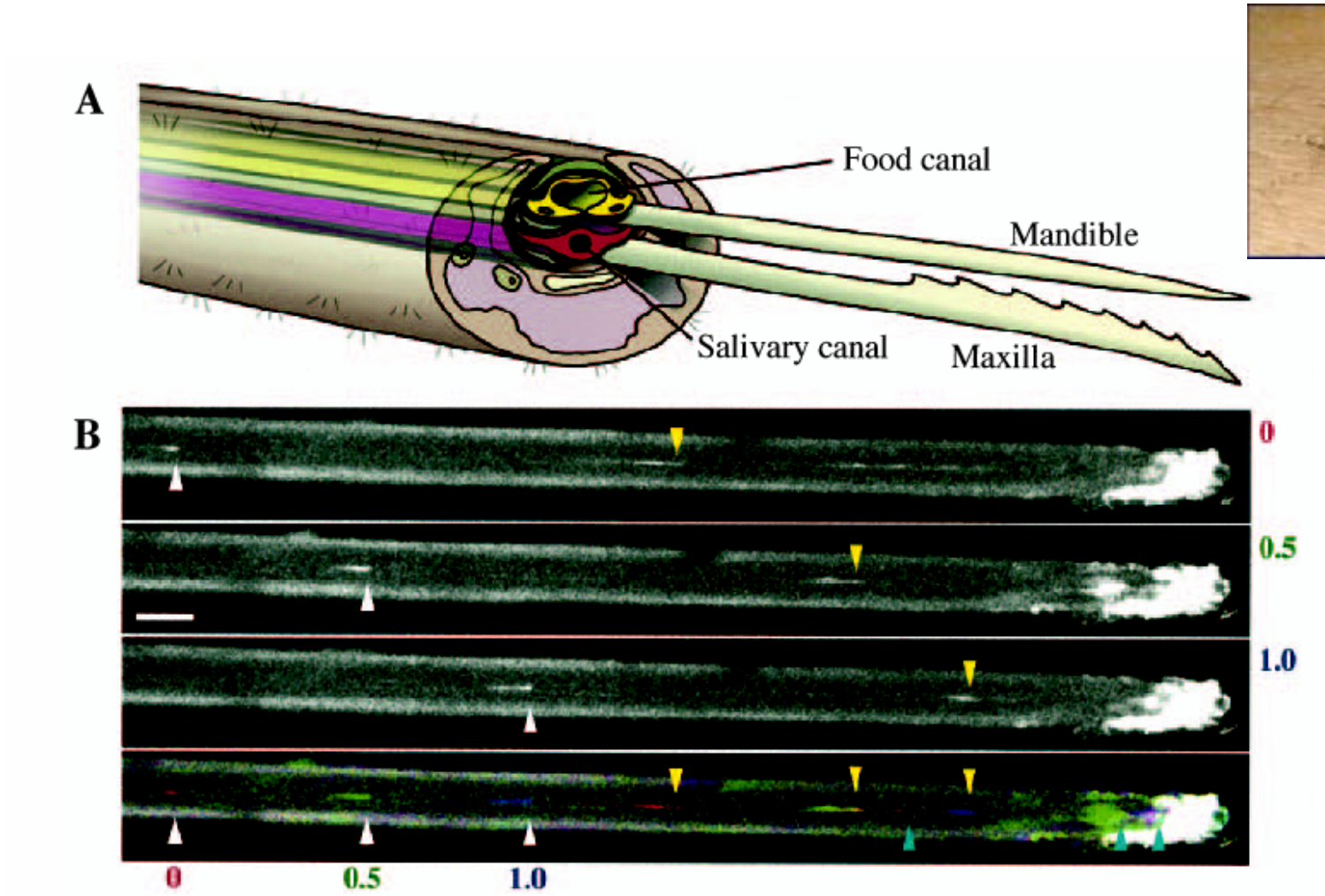
Phenotypic differences of oocyst sporozites and salivary gland sporozoites



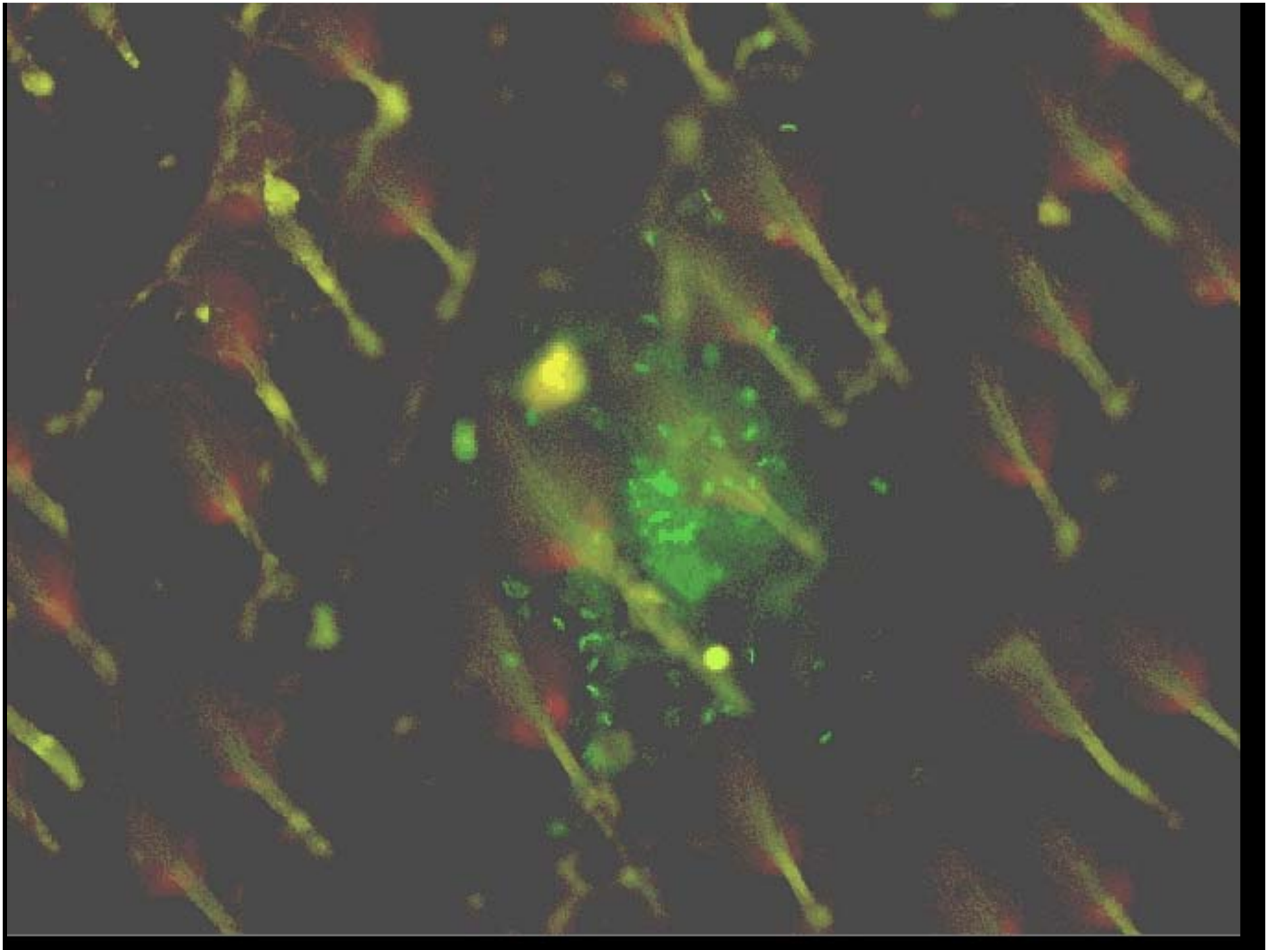
midgut-oocyst	salivary gland
oocyst sporozoites	sporozoites
non-virulent do not elicit protection discontinuous gliding	virulent elicit protection continuous gliding

Matuschewski K. *et al*. 2002 **J Biol Chem** 277: 41948

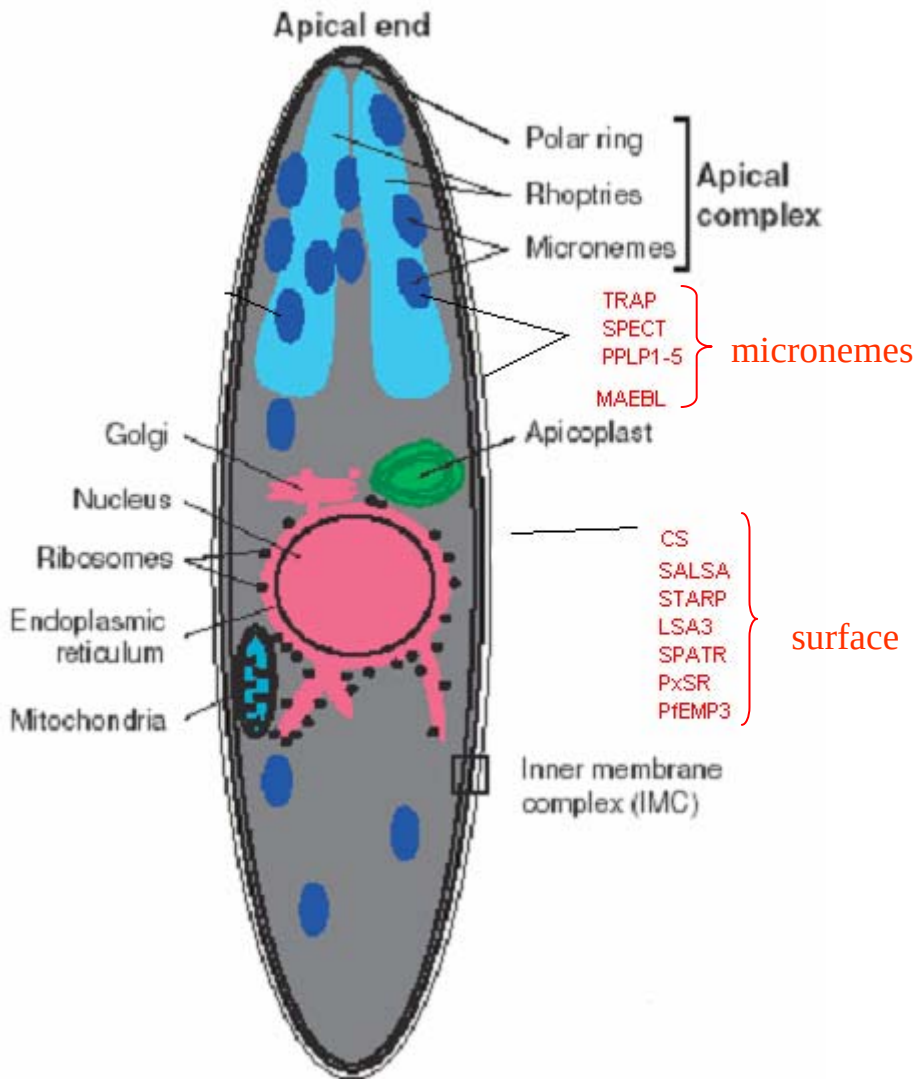
Sporozoite ejection through the salivary canal of a live mosquito's proboscis



Frischknecht F et al. 2004 **Cellular Microbiologi**. 6: 687

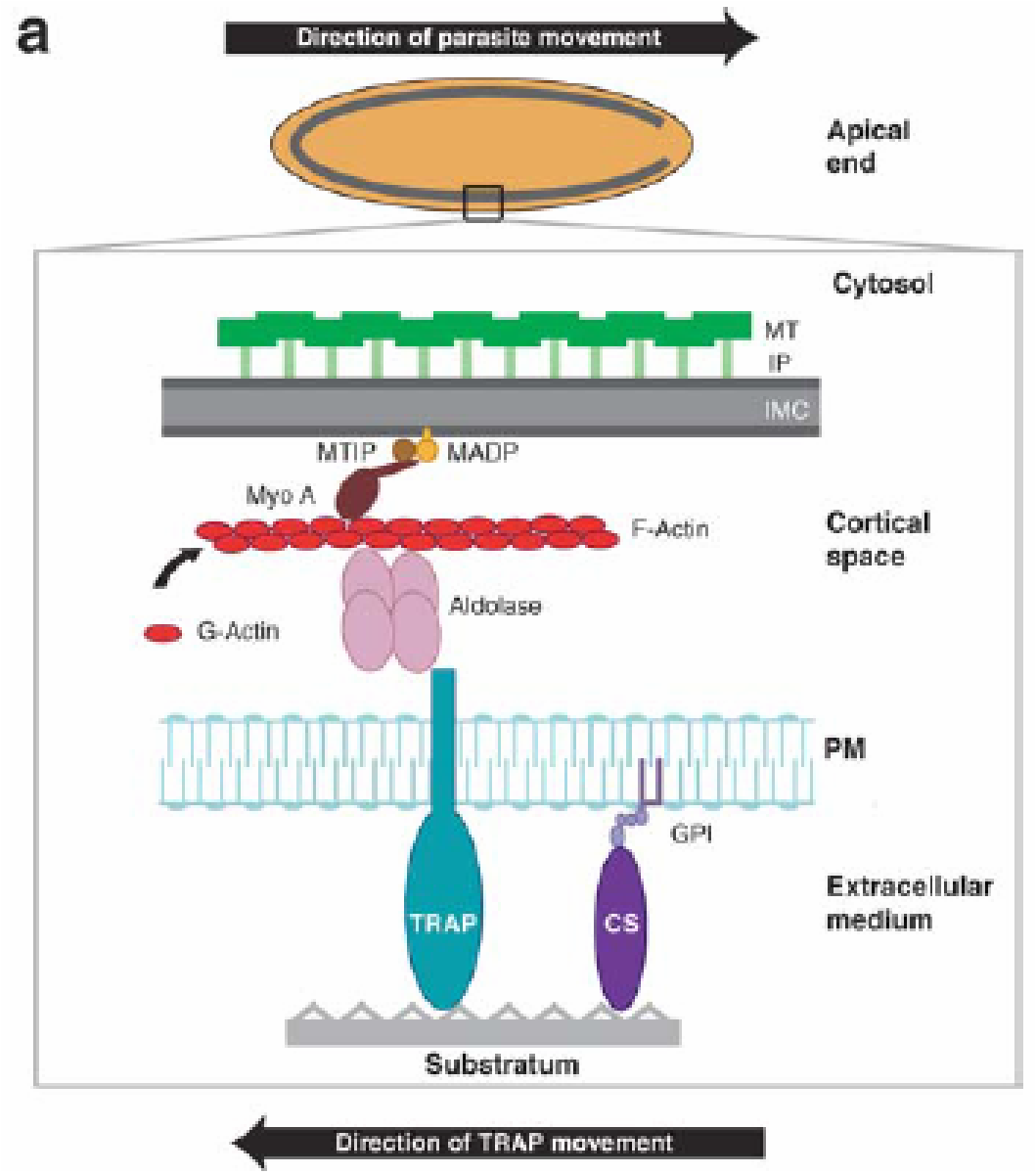


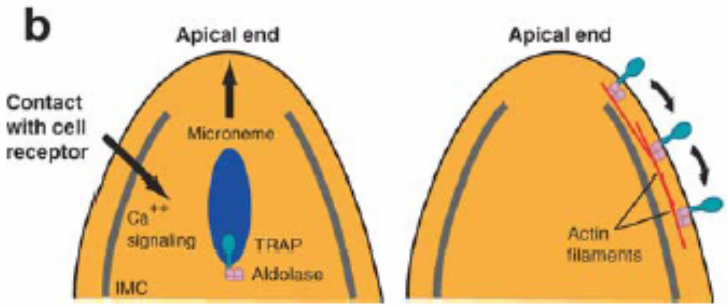
Schematic representation of a *Plasmodium*



Kappe Stefan H. I. *Et al* 2004. **Annu. Rev. Cell Dev. Biol**.. 20: 29-59

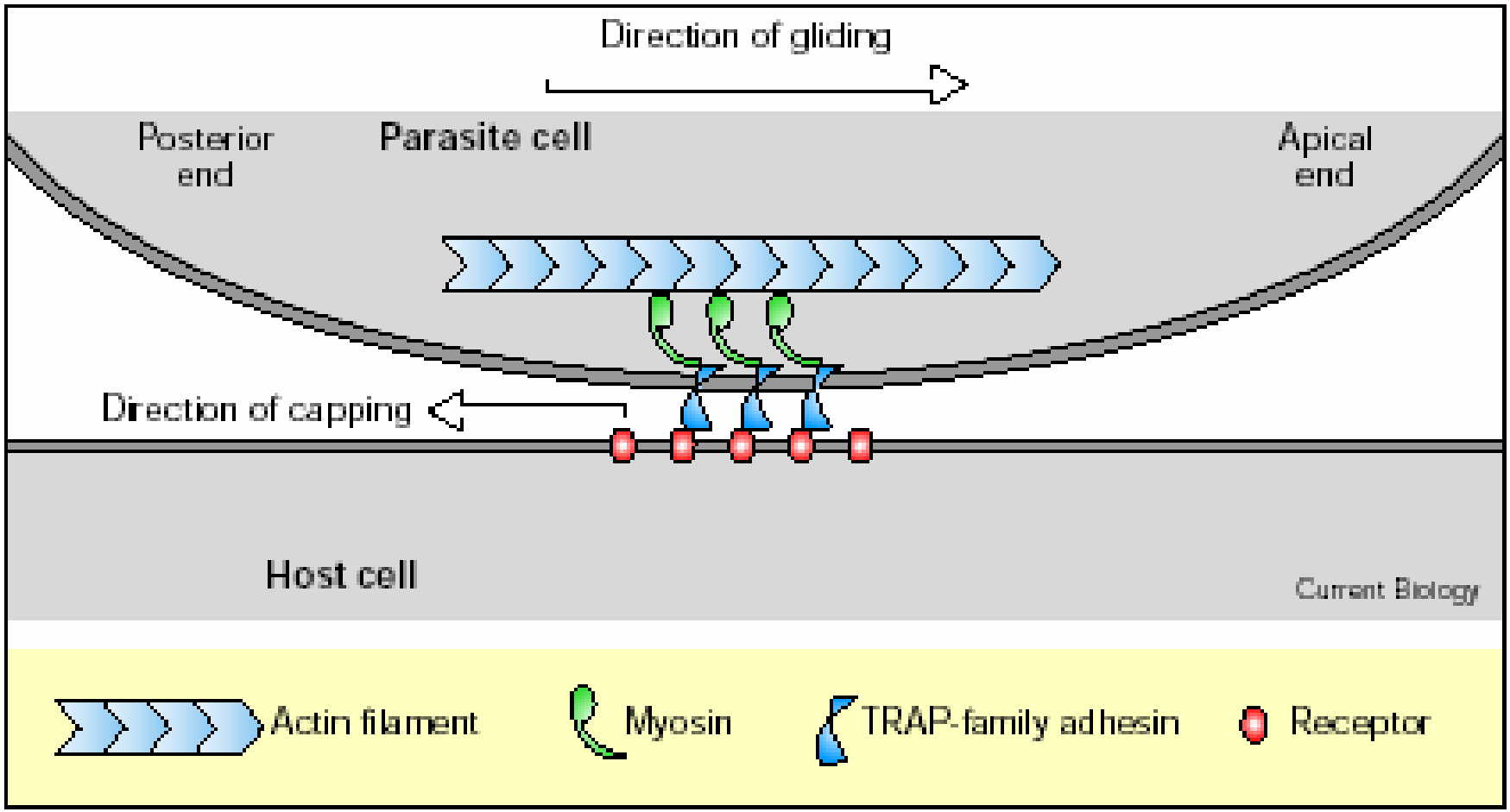
Model of molecular motility machinery in apicomplexa





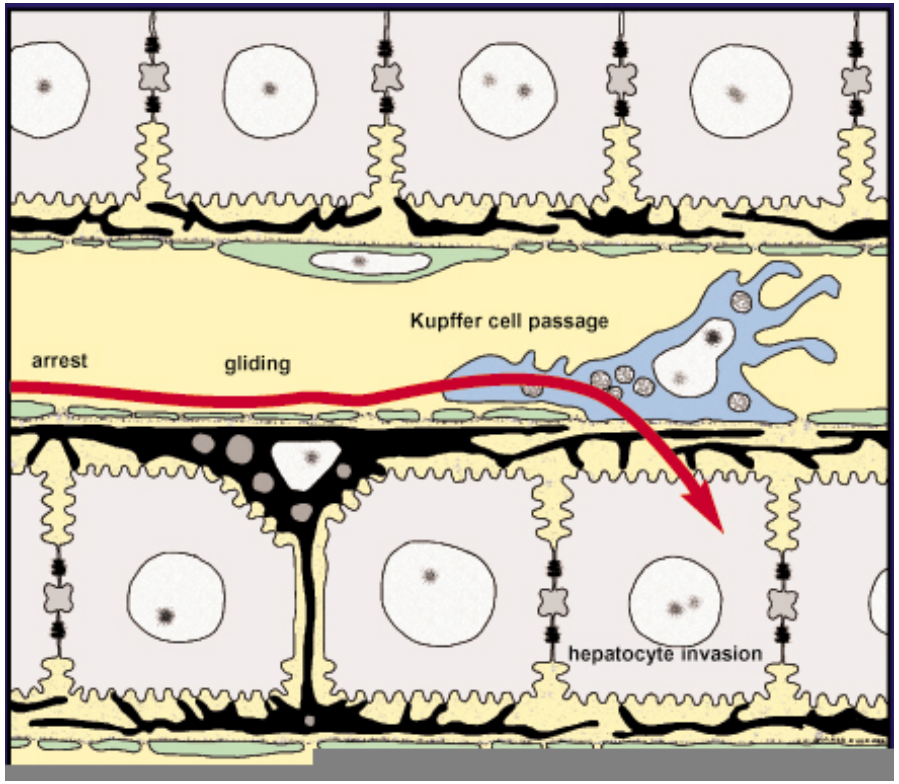
Kappe Stefan H. I. *et al.* 2004. **Annu. Rev. Cell Dev. Biol.**. 20: 29

Model of molecular motility machinery in apicomplexa

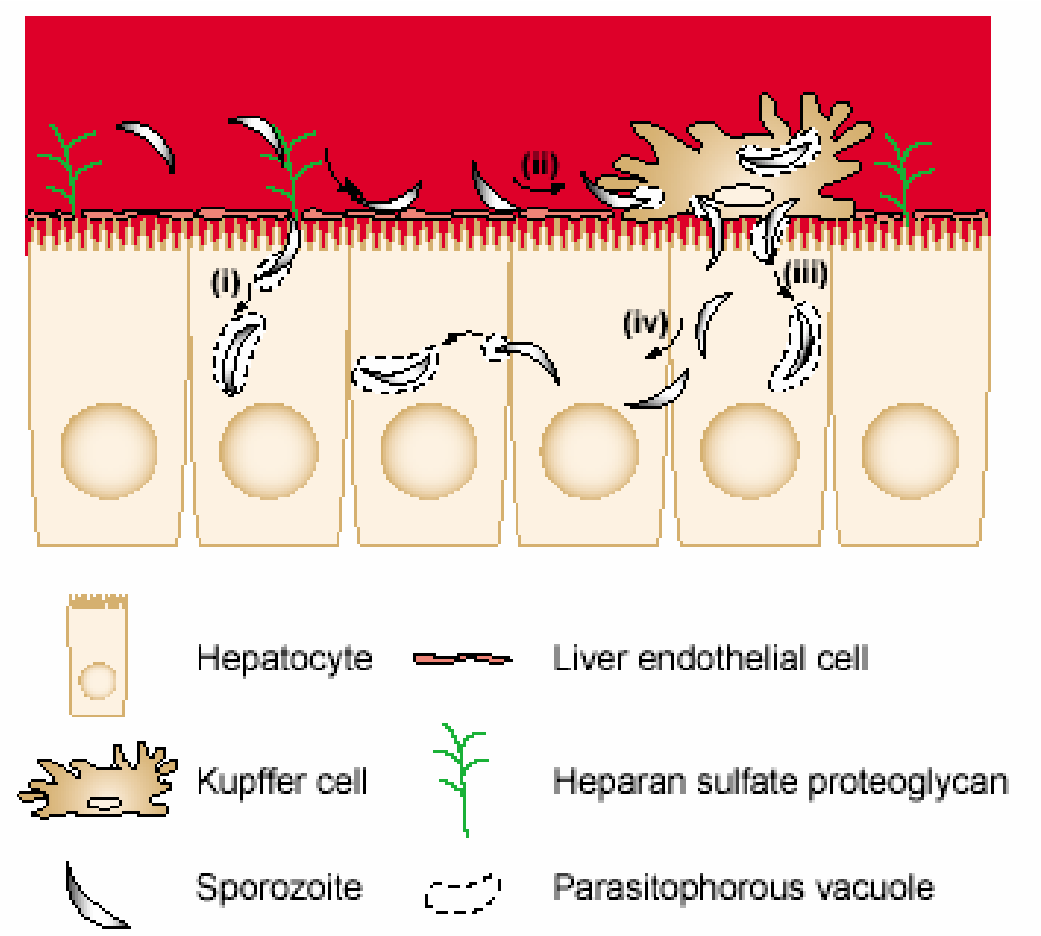


Sibley D, et al, 1998, **Current biol.** 8:R12

Malaria sporozoites actively enter and pass through Kuppffer cells prior to hepatocyte invasion

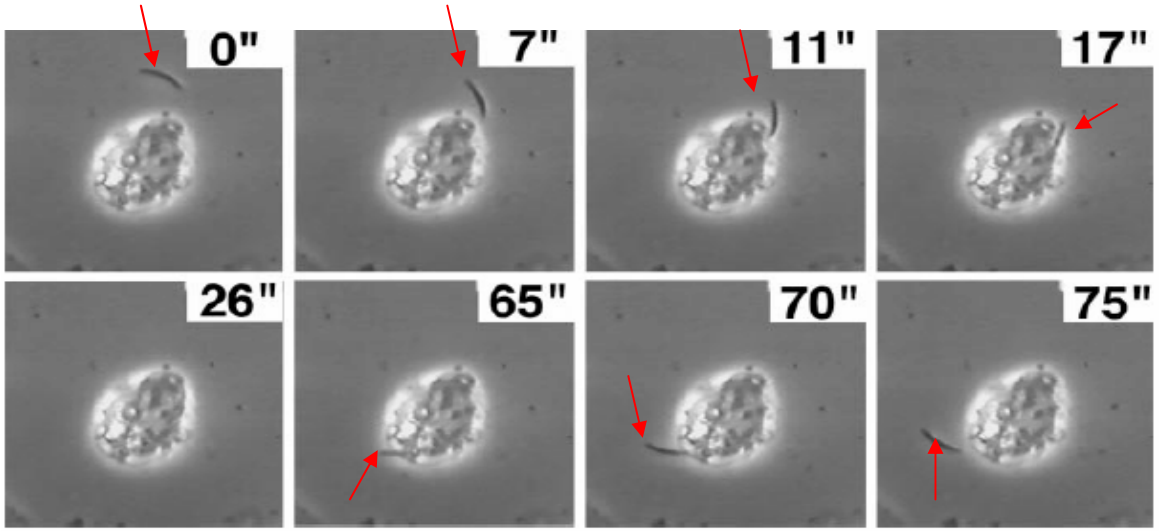


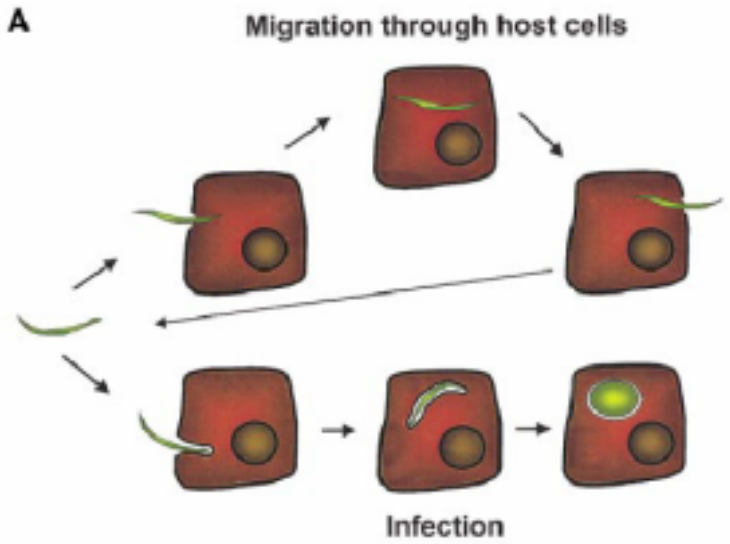
The complexity of sporozoite liver infection



Kappe S et al, 2003, **Trends Parasitol**. 19:135

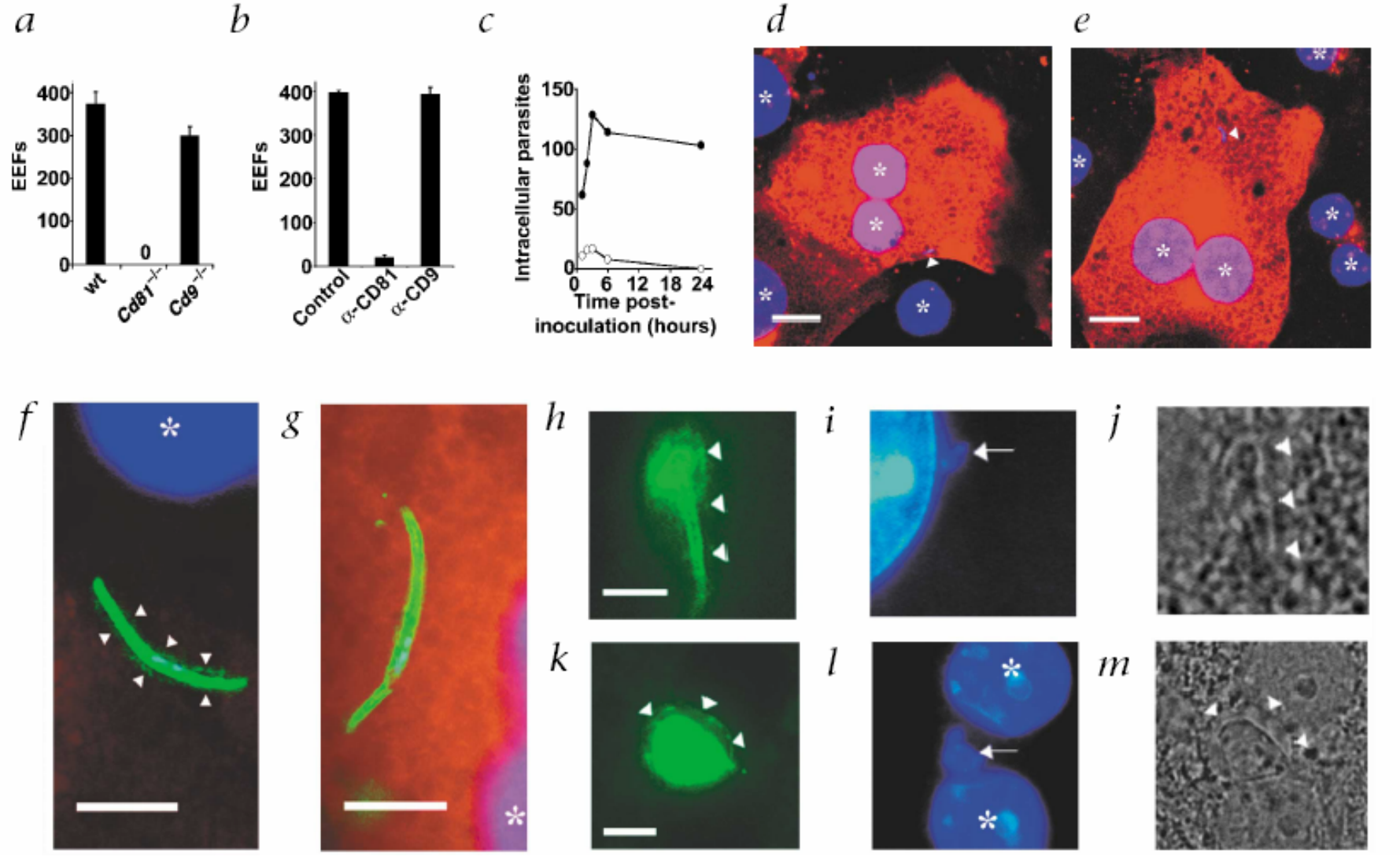
Plasmodium sporozoites migrate through hepatocytes before infection





Mota M.M. *et al*. 2001 Sciencie :291: 141

CD81 is required by *P yoelli* sporozoites for hepatic infection



Silvie O. et al. 2003 **Nature Med**. 9:93

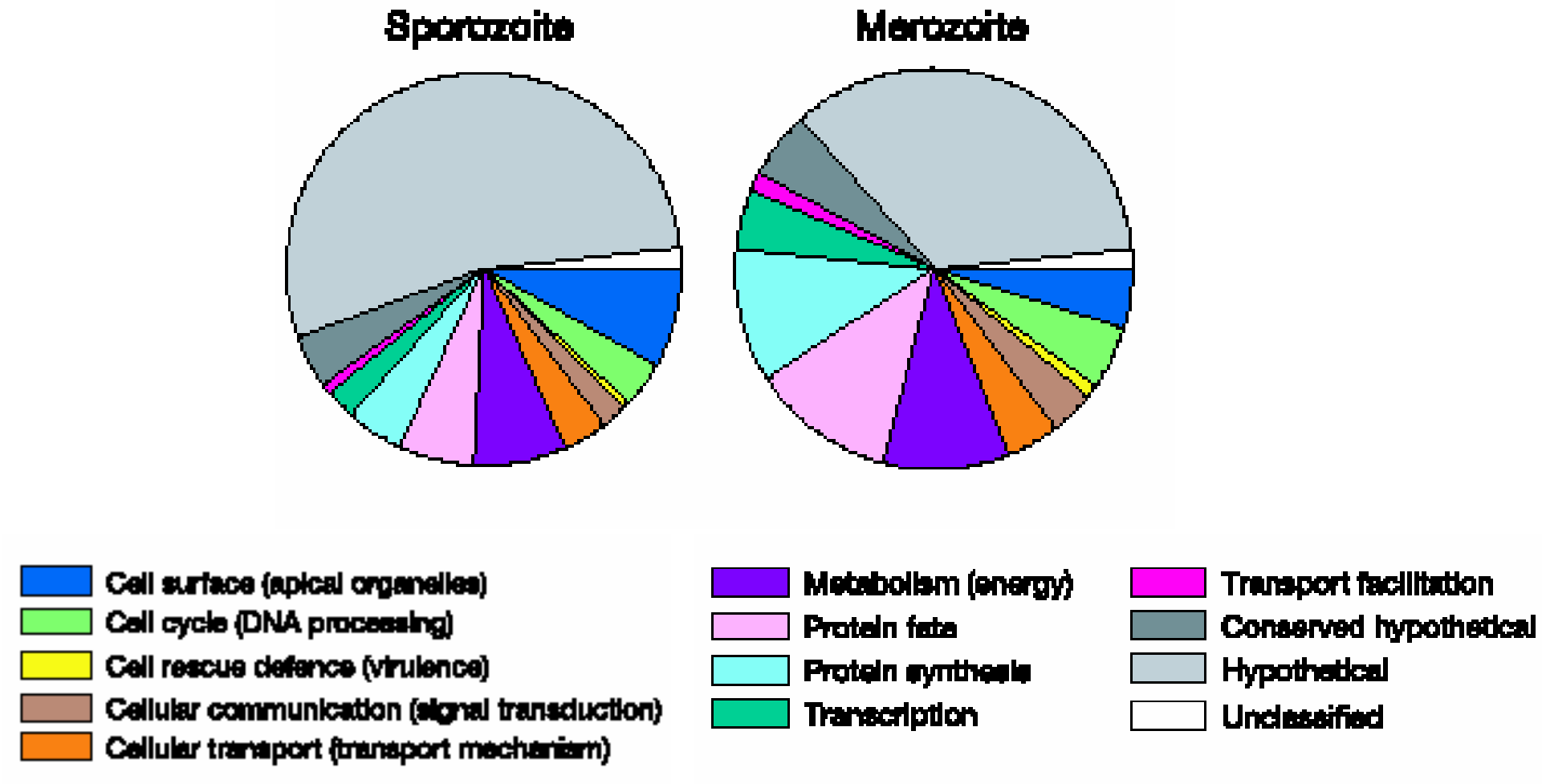
Electron micrograph of an early hepatic schizont

Knell A.J. 1987. **Am J Trop Med Hyg**. 37:412

Plasmodium berghei exo-erythrocyte schizont in HepG2 cells

www.bio.ic.ac.uk/researh/res/sinden.htm

Functional profile of proteins expressed in different *P. falciparum* life-cycle stages



Florens L. *et al.* 2002 **Nature** 419 520

Table 1. Comparative summary of the protein lists for each stage

Protein count	Sporozoites	Merozoites	Trophozoites	Gametocytes
152	X	X	X	X
197	-	X	X	X
53	X	-	X	X
28	X	X	-	X
36	X	X	X	-
148	-	-	X	X
73	-	X	-	X
120	X	-	-	X
84	-	X	X	-
80	X	-	X	-
65	X	X	-	-
376	-	-	-	X
286	-	-	X	-
204	-	X	-	-
513	X	-	-	-
2,415	1,049	839	1,036	1,147

Whole-cell protein lysates were obtained from, on average, $17x10^6$, $4.5x10^9$ trophozoites, $2.75x10^9$ merozoites, and $6.5x10^9$ gametocytes.

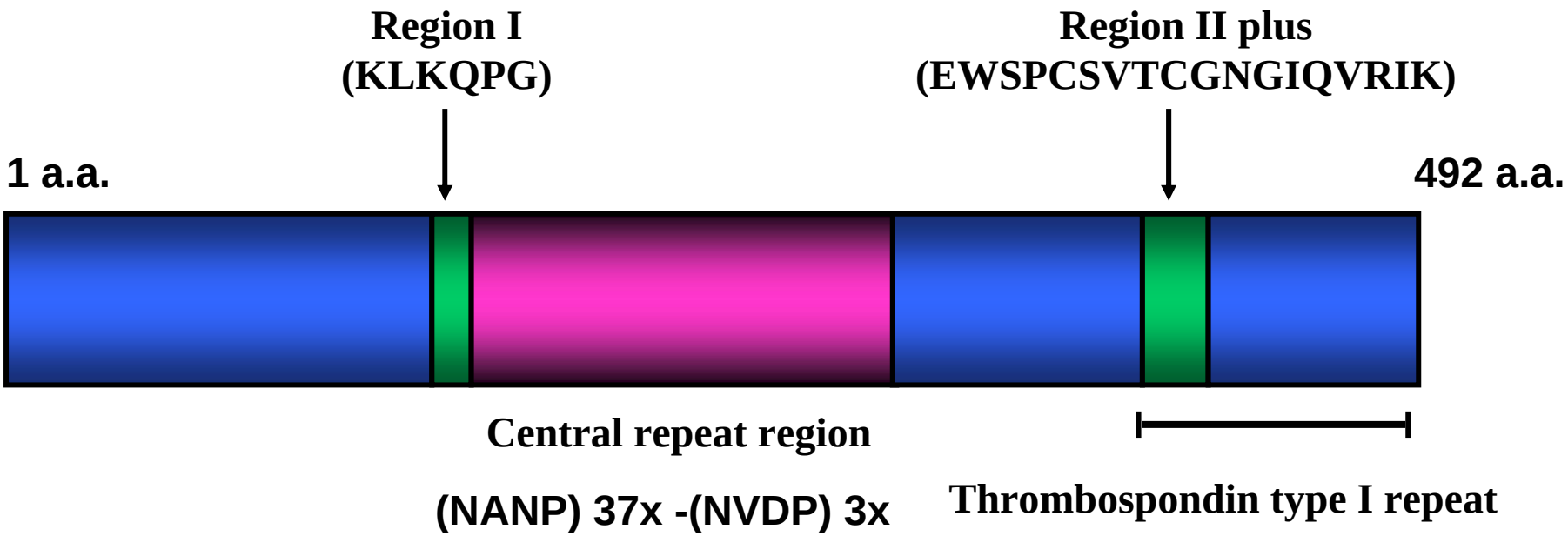
Florens L. *et al.* 2002 **Nature** 419:520

Plasmodium sporozoite surface and/or apical organelle proteome

Protein	Other stages[c]	Subcellular localization
CS	–	Surface
TRAP	–	Surface, micronemes
MAEBL	–	Surface, micronemes
SPECT	–	Micronemes
EBA175	Mz	Surface, micronemes
P235[a]	Mz	Rhoptries
AMA1	Mz	Surface, micronemes
STARP	RBC, LS	Surface
SALSA	RBC, LS	Surface
PEMP3	RBC, LS	Surface
LSA3	LS	Surface
P52	–	?
MCP1	Mz	?
SPATR	RBC	Surface
PPLP1	–	Micronemes
PfEMP1[a,b]	iRBC	?
STEVOR[a,b]	iRBC	?
RIFINS[a,b]	iRBC	?

Baldacci P et al 2004 **Mol microbiol**.

Circumsporozoite protein (Cs)
(42 kDa)



Localisation:

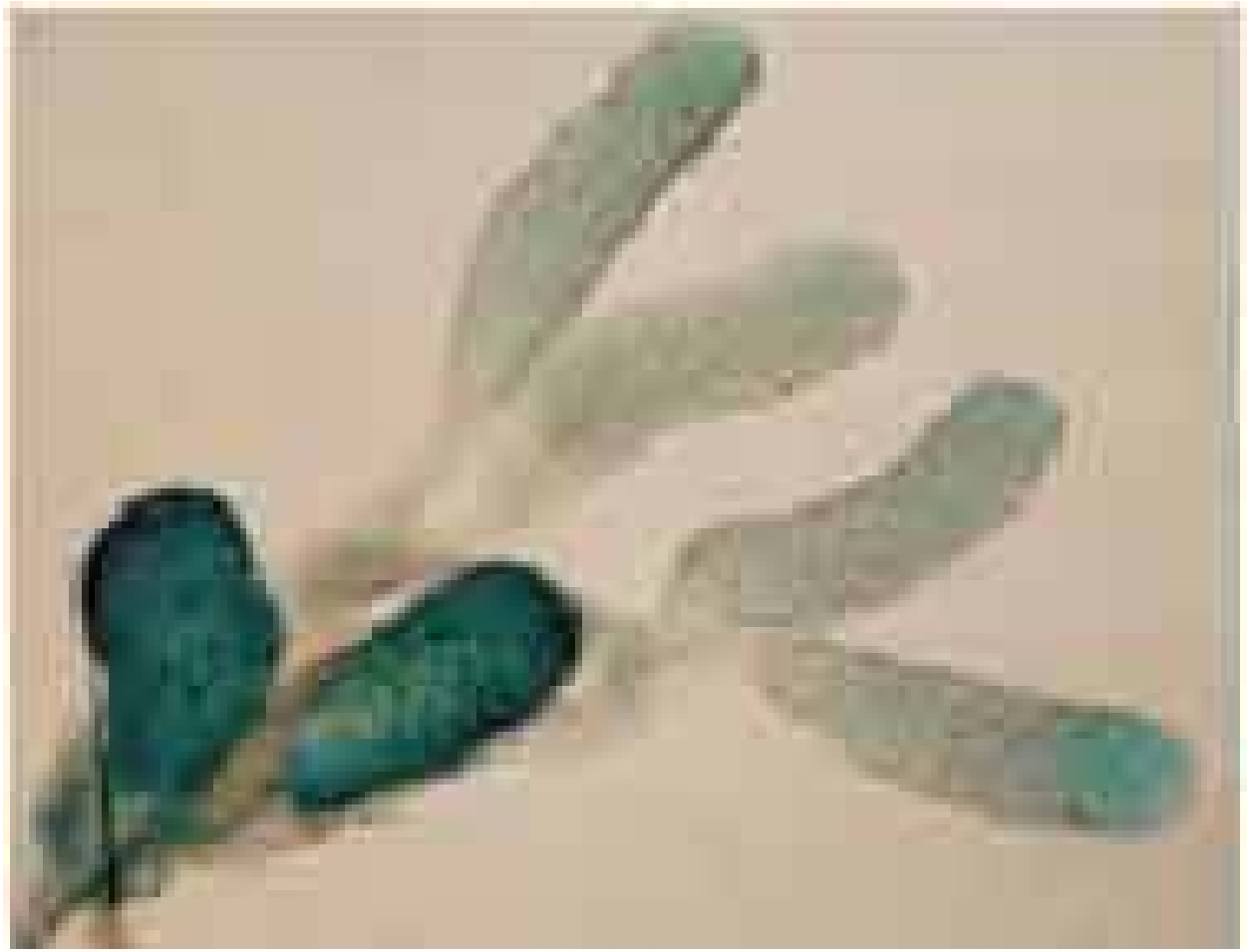
Surface Spz, EEFs, Liver Stage

Possible function:

Adhesion, Invasion, glinding motility

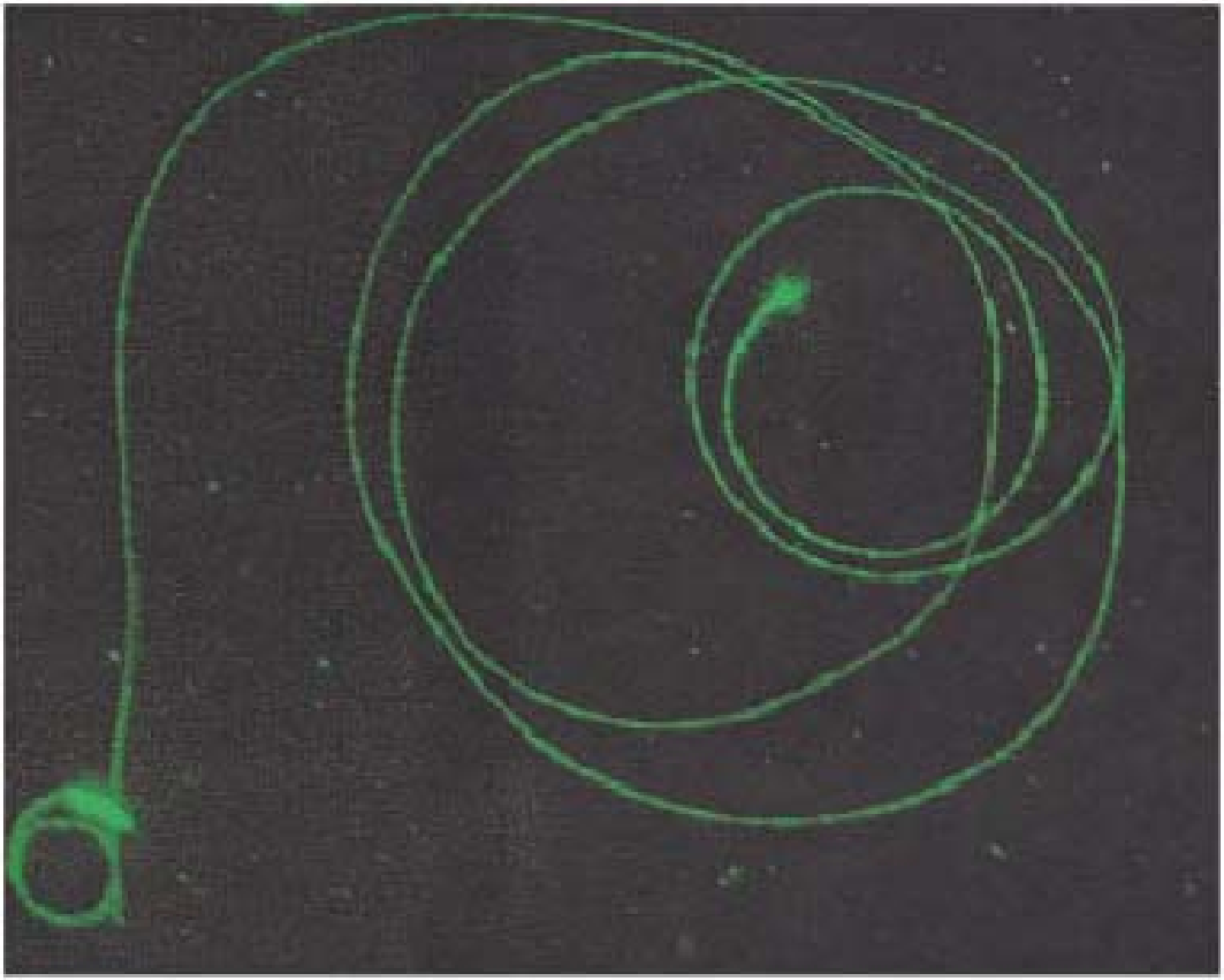
Kappe S. H. *et al*. **2003 Trends Parasitol** 19:135

Salivary gland tinction with CS protein



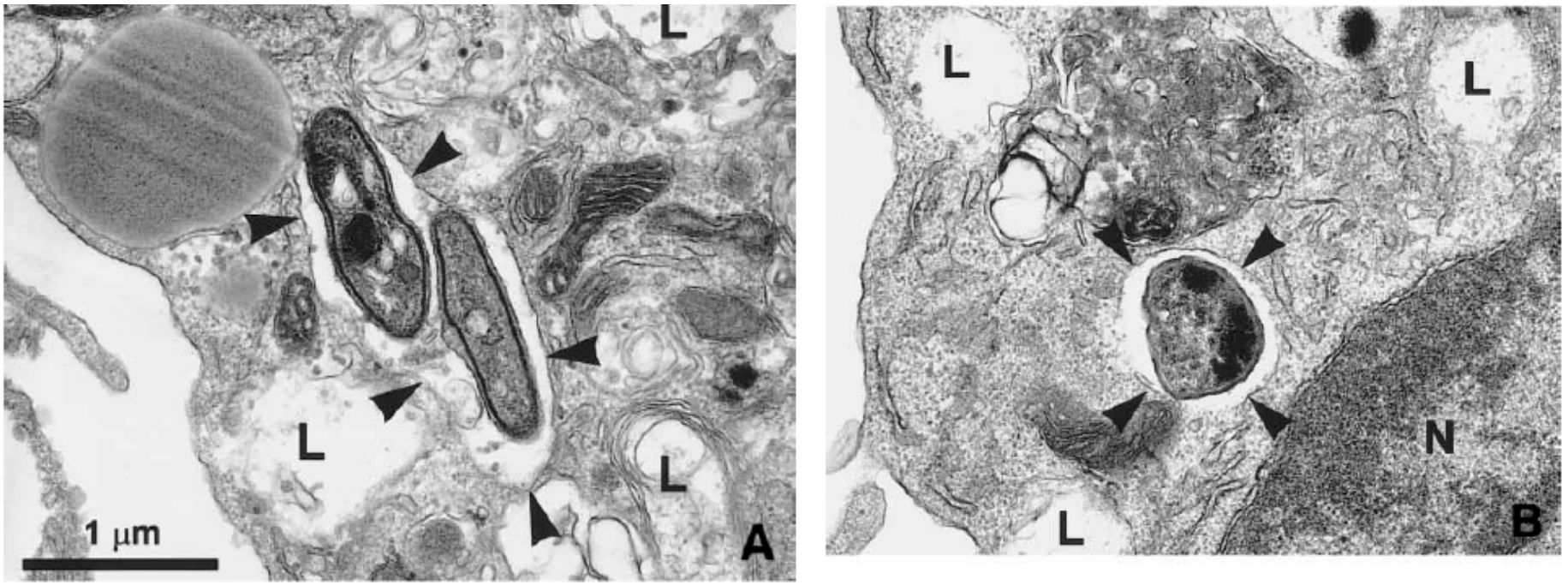
http://www.med.nyu.edu/parasitology/research/psinnis.html

Sporozoite displacement in an assay with CS protein



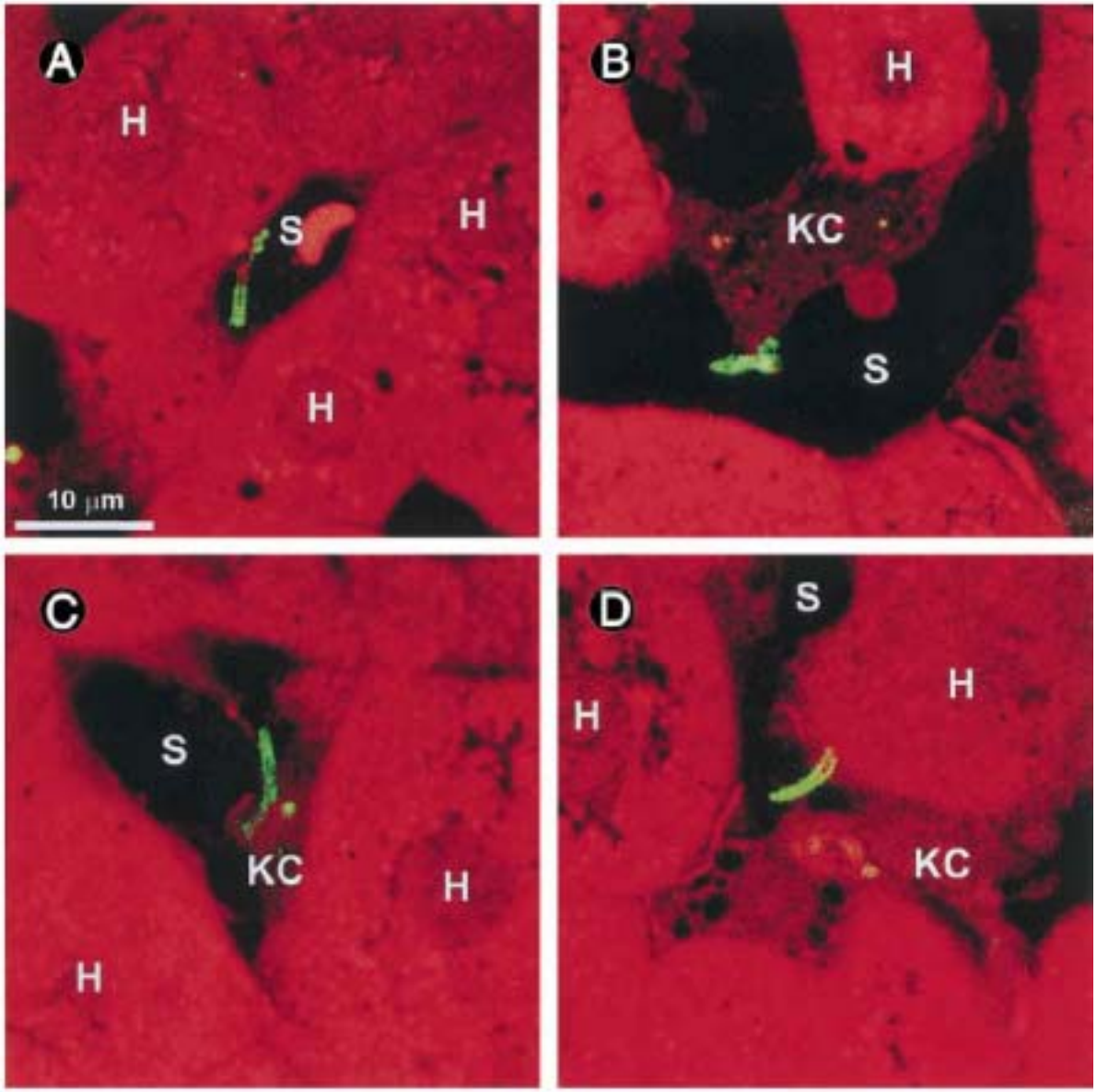
Mota M.M. *et al* **2002 Bio assayss** 24, 149

Sporozoites are enclosed in a vacuole in Kupffer cells



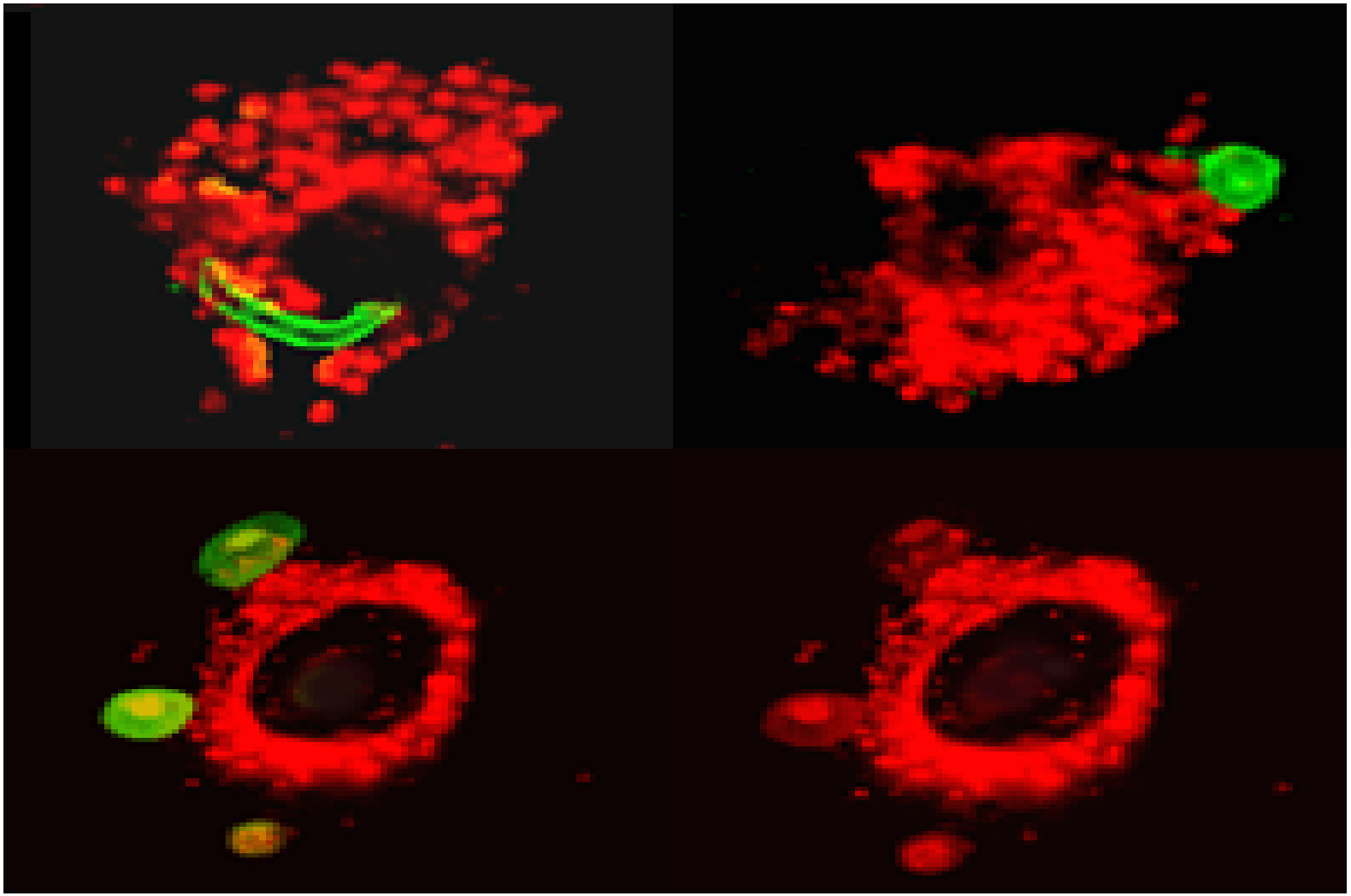
Pradel and Frevert. 2001 **Hepatology,** 33,1154

P. bergei sporozoites pass through Kupffer cells to hepatocytes *in vivo*



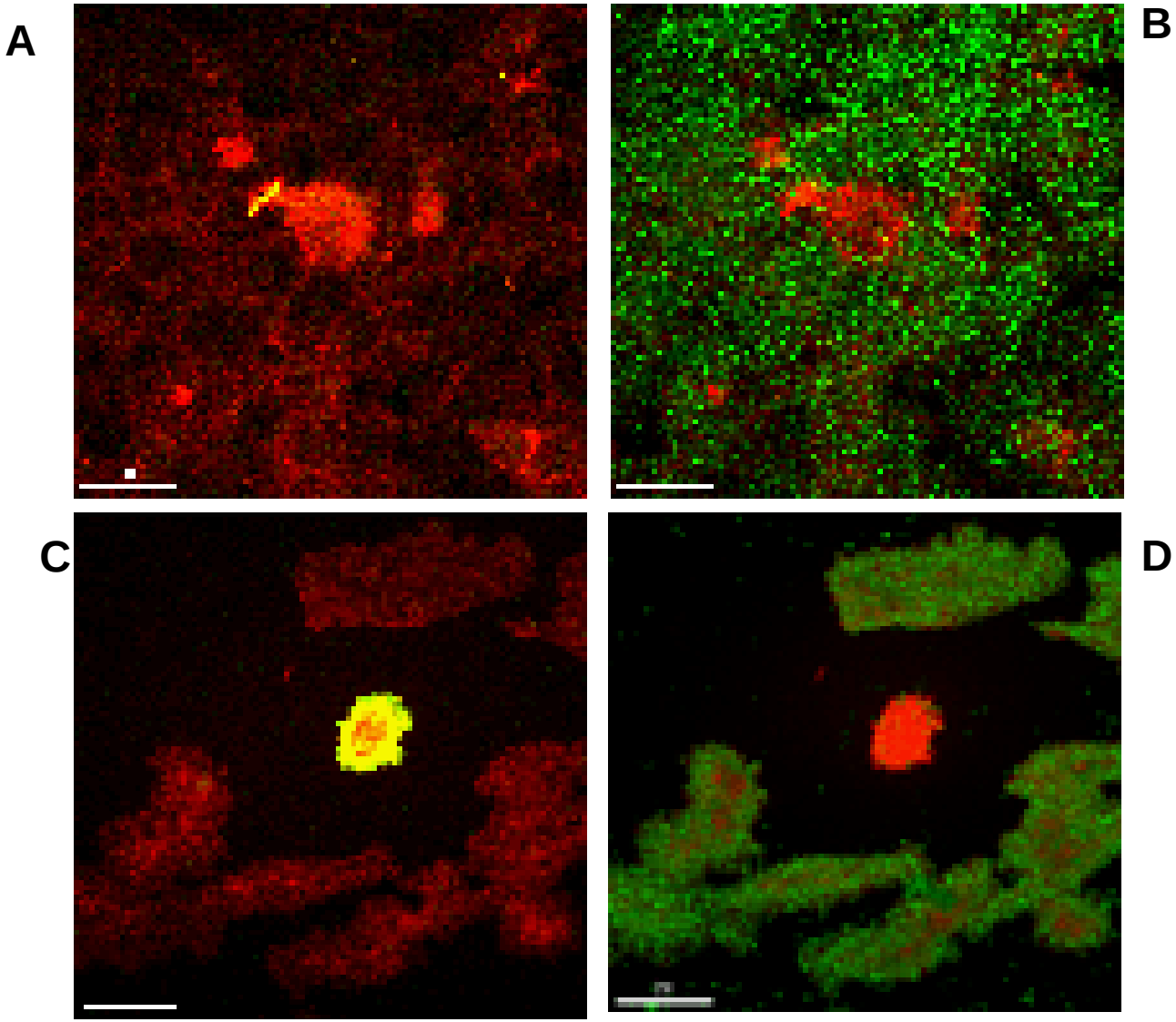
Pradel and Frevert. 2001 **Hepatology**. 33:1154

The parasitophorous vacuole enveloping the sporozoite in Kupffer cells there is no binding to lysosomes



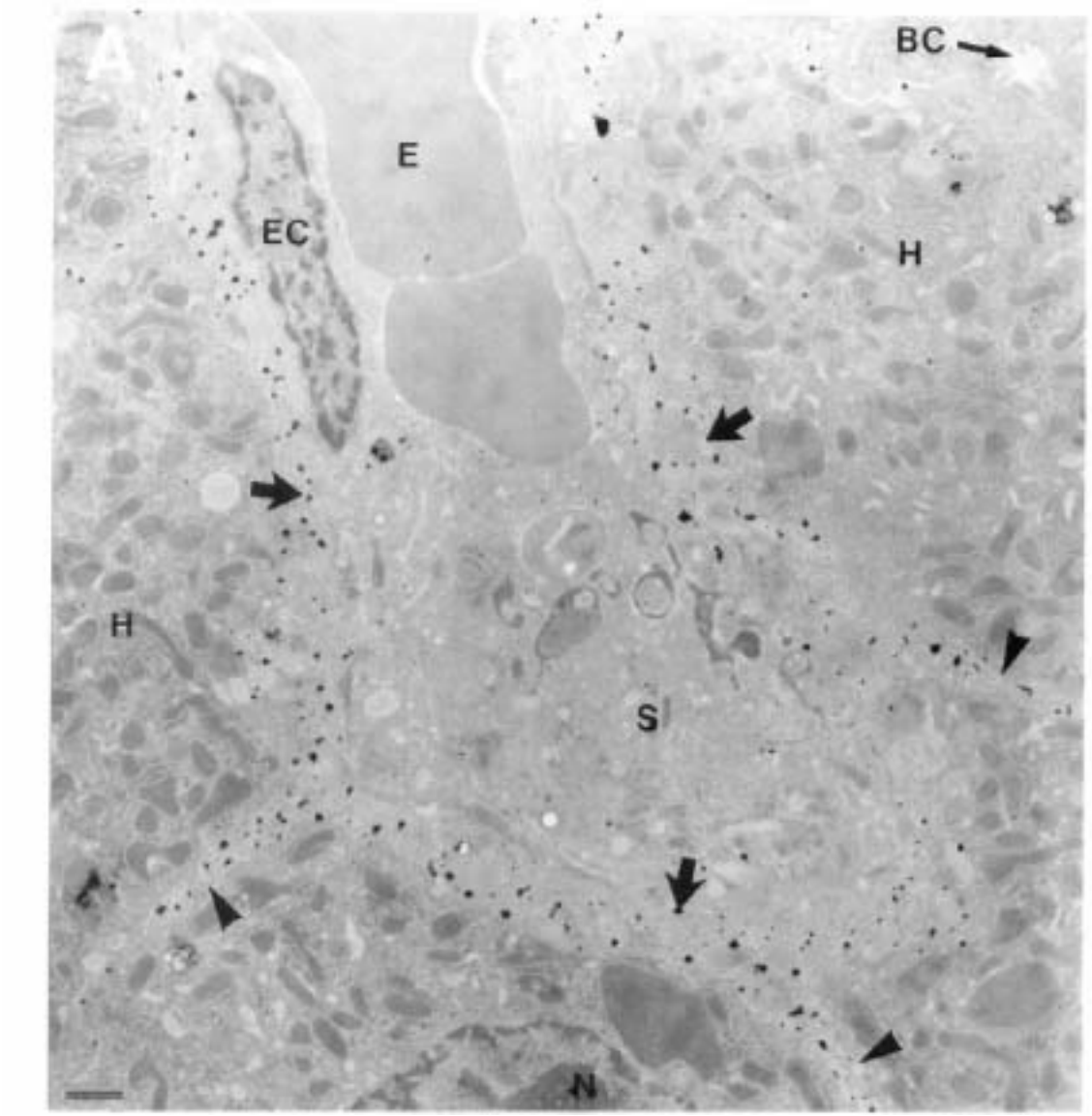
www.med.nyu.edu/parasitology/ research/ufrevert.html

CS protein inhibition of protein synthesis in mammal cells



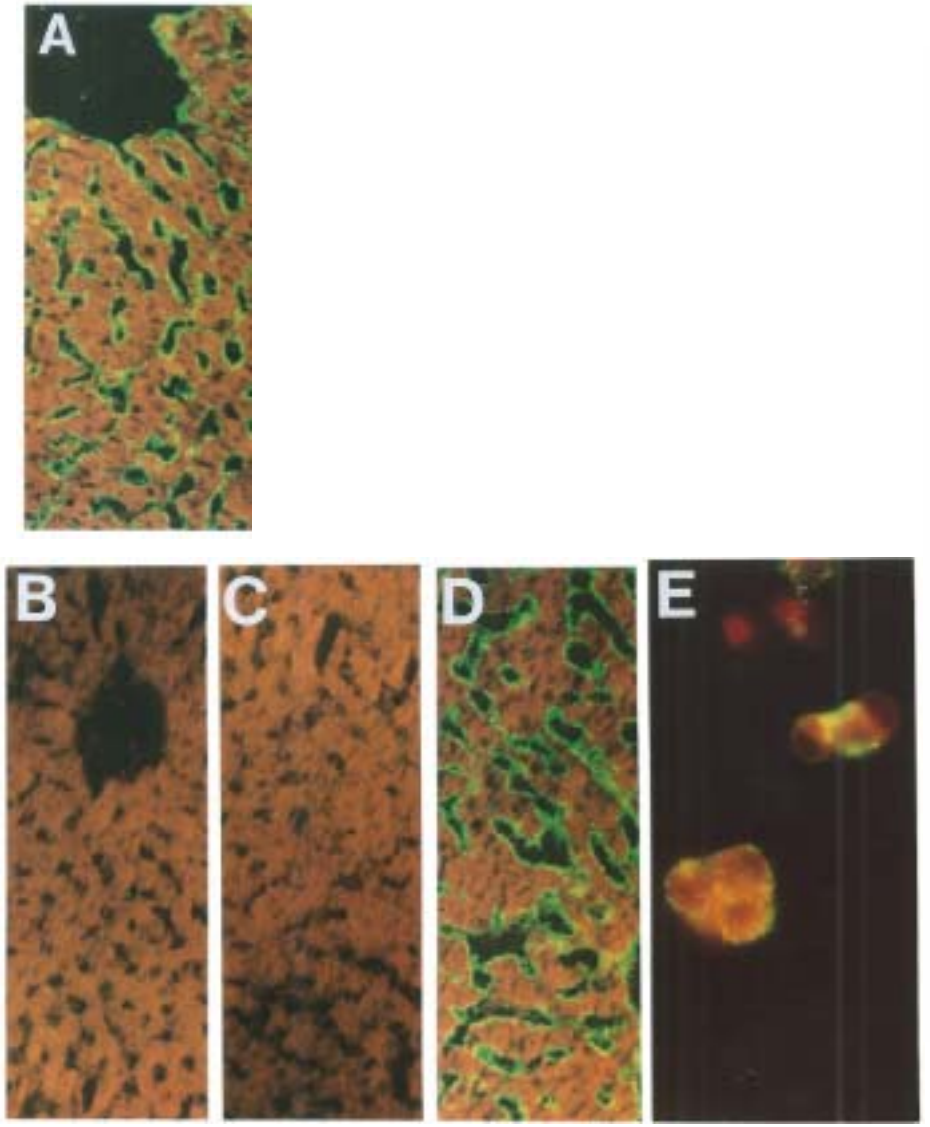
www.med.nyu.edu/parasitology/ research/ufrevert.html

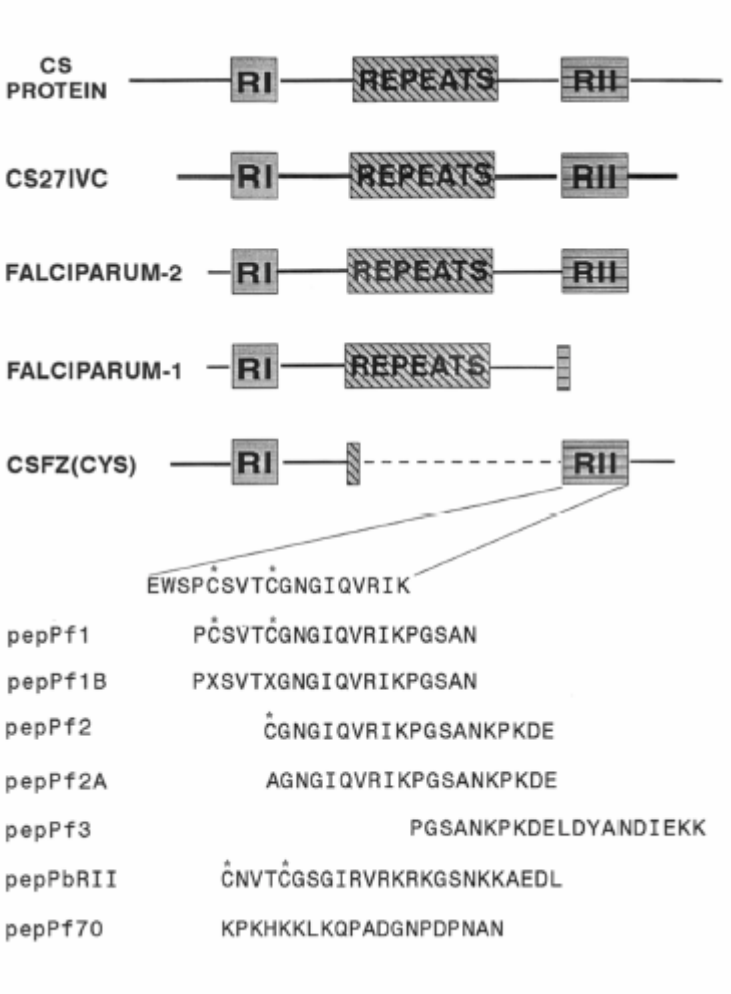
CS protein binding to human hepatocyte microvilli in the Disse space



Cerami C. *et al* . **1992 Cell,** 70:1021

CS protein binding in the liver depends on region II

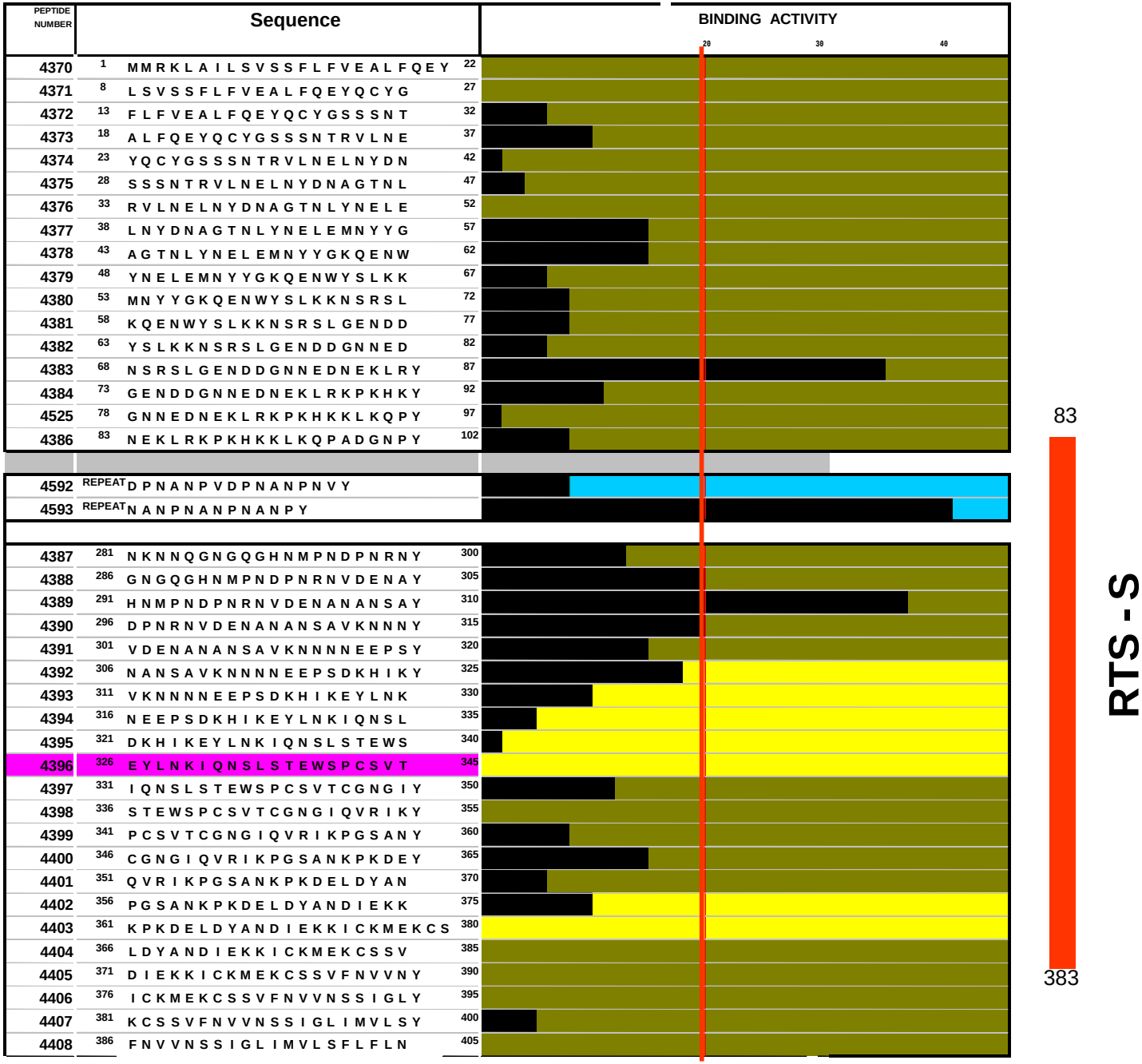




Cerami C. *et al* . 1992 **Cell** 70:1021

Plasmodium falciparum circumsporozoite (CS) protein peptides specifically bind to HepG2 cells

Suarez J, et al, 2001, **Vaccine**,19:4487



CS peptides specifically binding to HepG2 cells

Suarez J, et al, 2001**, Vaccine**,19:4487

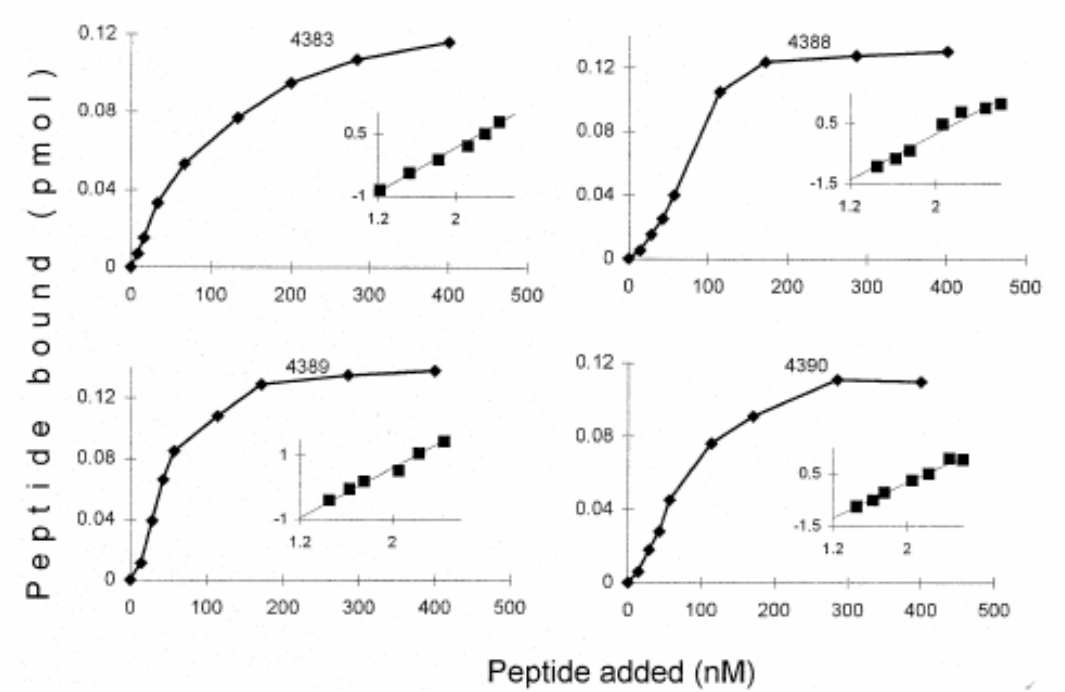
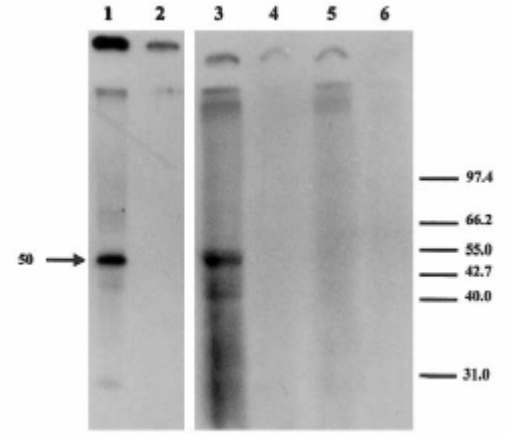


Table 1
Binding constants of CS peptides to HepG2 cells

Peptide	Kd (nM)	*n*	Binding sites per cell
4383	80 ± 8	1.0 0.1	120 000 ± 11 500
4388	80 ± 11	2.0 0.2	140 000 ± 12 000
4389	50 ± 6	2.0 0.2	140 000 ± 12 000
4390	80 ± 9	2.0 0.2	120 000 ± 10 000



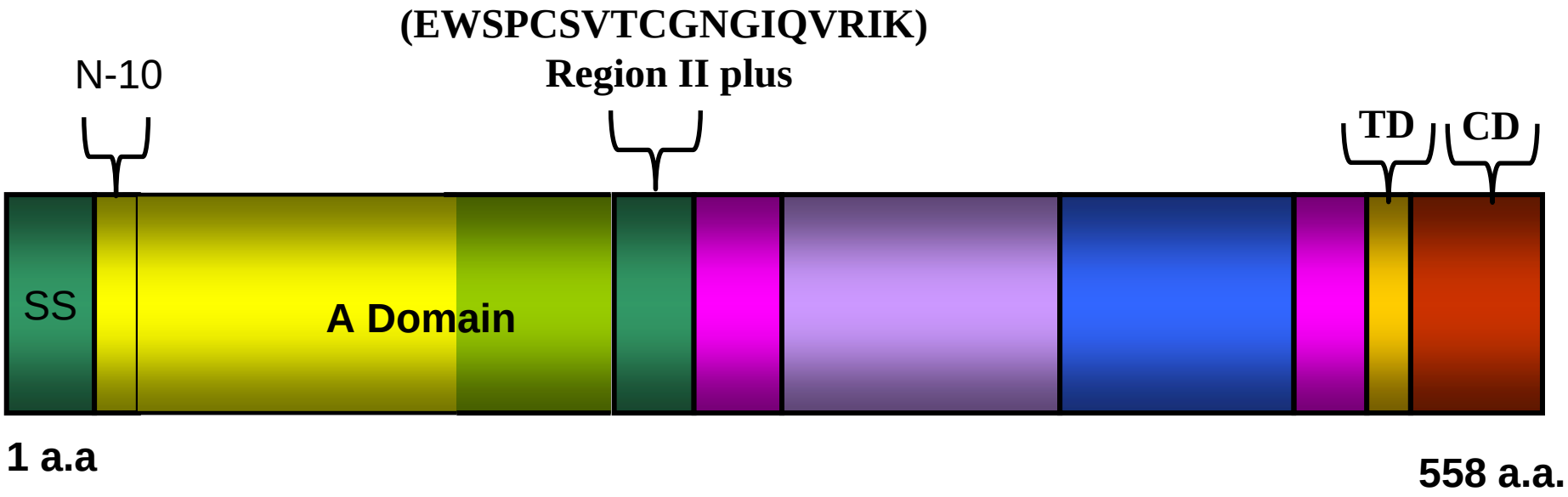
Polimorphic sequence found in different *P. falciparum* isolates Corresponding to amino acids 326 to 345 Of the NF54 *P. falciparum*

Moreno A. et al. 1993 **J Immunol**. 151:489.

Isolates	Origin	Sequence
NF54,$XP_{8,9}$, $X_{10,11}$,$427_{1-4,6-10}$ 3D7	Wets Africa, Honduras, The Netherlands	**E Y L N K I Q N S L S T E W S P C S V T**
ltG2G1	Brazil	**K K**
MS2,SO6	Thailand, Brazil	**K K R**
LE5, 366_{9}	Liberia, Gambia	**K K T**
366_{t}, 399_{1-10}, 406_{1-9}, 419_{10}	Gambia	**K K T K**
$366_{8,10}$	Gambia	**K Q**
406_{10}, 419_{1-9}	Gambia	**K Q K**
366_{2-7}	Gambia	**K Q R**
Xs,$XP_{12,13}$ HB3, D10, T4, T9-101, WEL, B11, PA, FCR3	Honduras, The Netherlands, Papua New Guinea, Thailand, West Africa, Uganda, Gambia	**Q K**
S24, T9-98	Angola, Thailand	**Q K T K**
7G8	Brazil	**Q K K I**

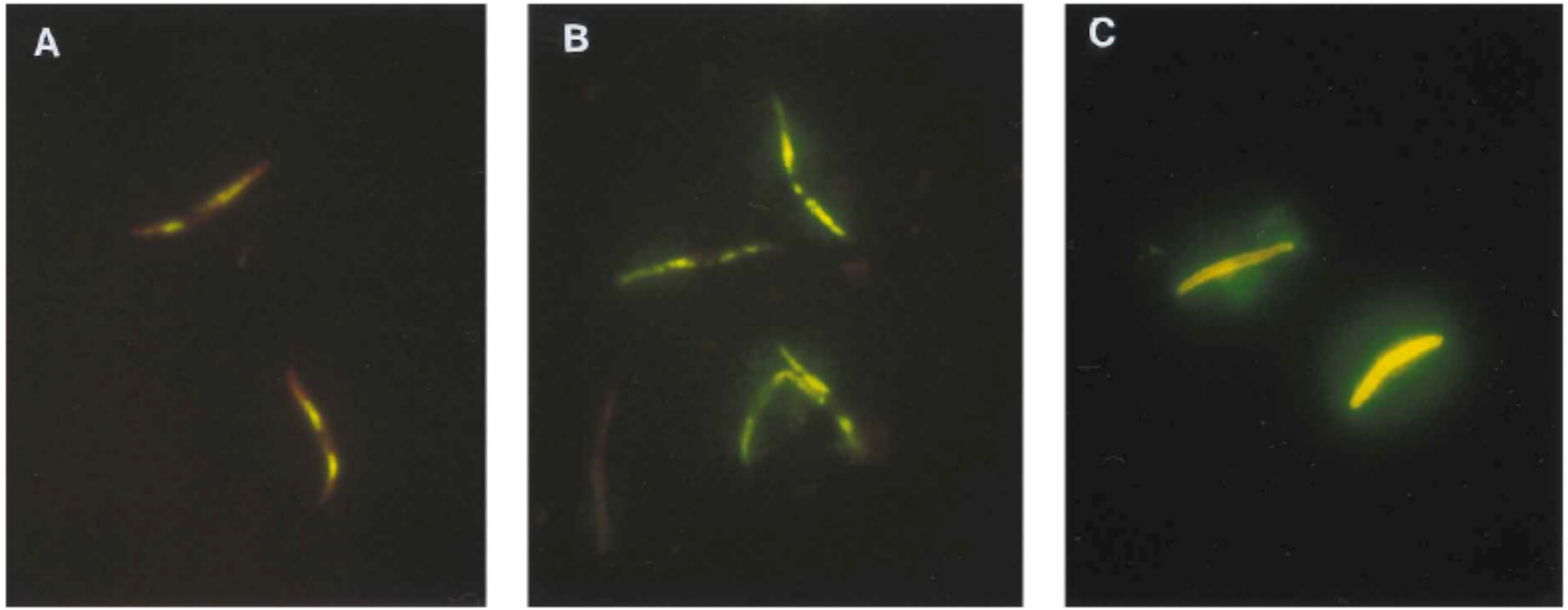
[a]Amino acids numbering is based on the CS protein of the NF54 strain of *P. falciparum* . The polimorphic residues are underline, and only amino acids that differ from the NF54 sequence are shown for each strain or isolate. The subscript numbers correspond to the isolate name described in materials and methods

Thrombospondin-Related Anonymous Protein (TRAP)/SSP2 (63 kDa)



Rogers O.W. *et al*. 1992 **PNAS** 89: 9176

IFAs of *P. falciparum SSP2* monoclonal and polyclonal antibodies against sporozoites

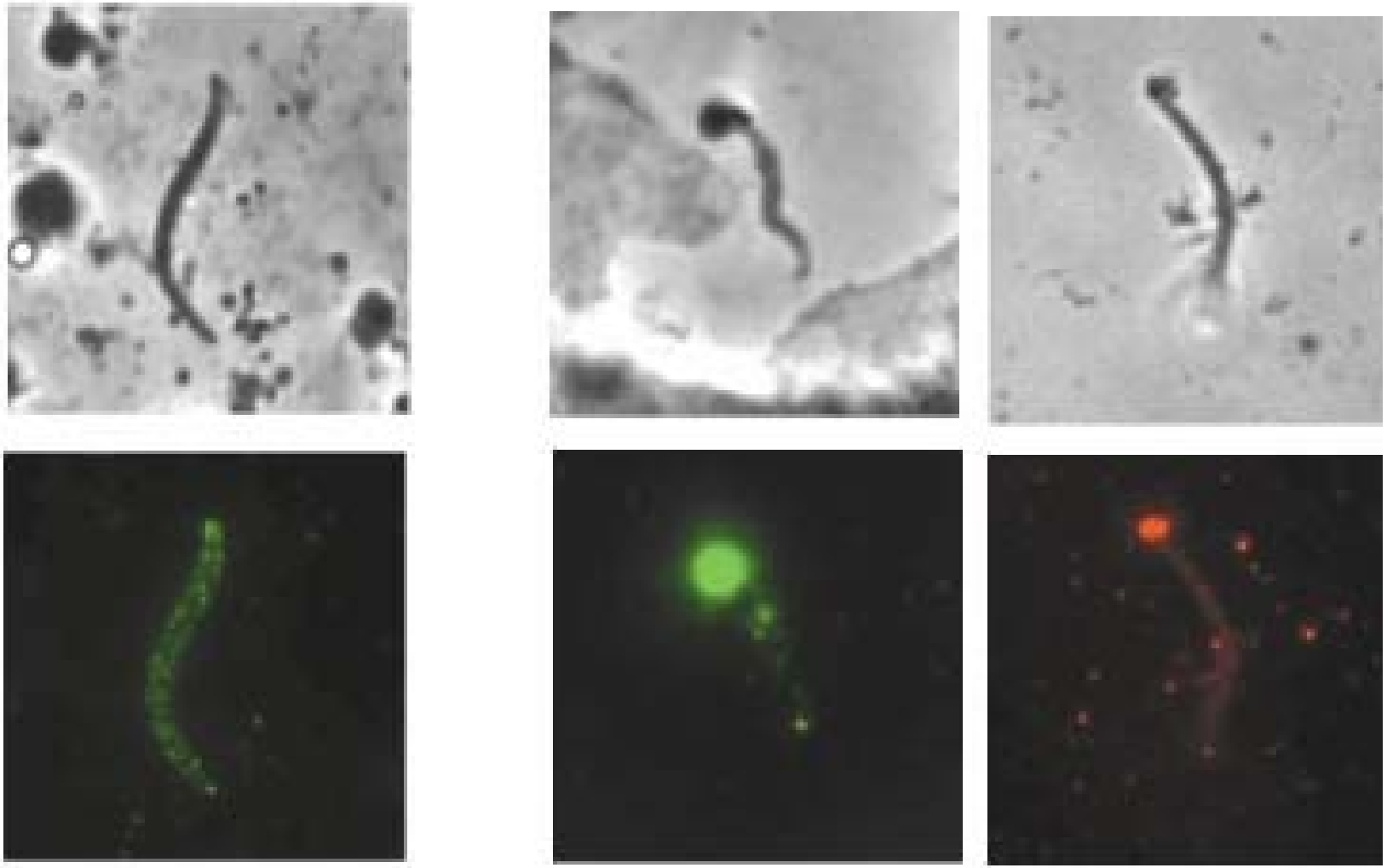


mAb SSP2 | α SSP2 | α CSP

Charoenvit Y. *et al*. 1997 **Infect. Immun**., 65: 3430

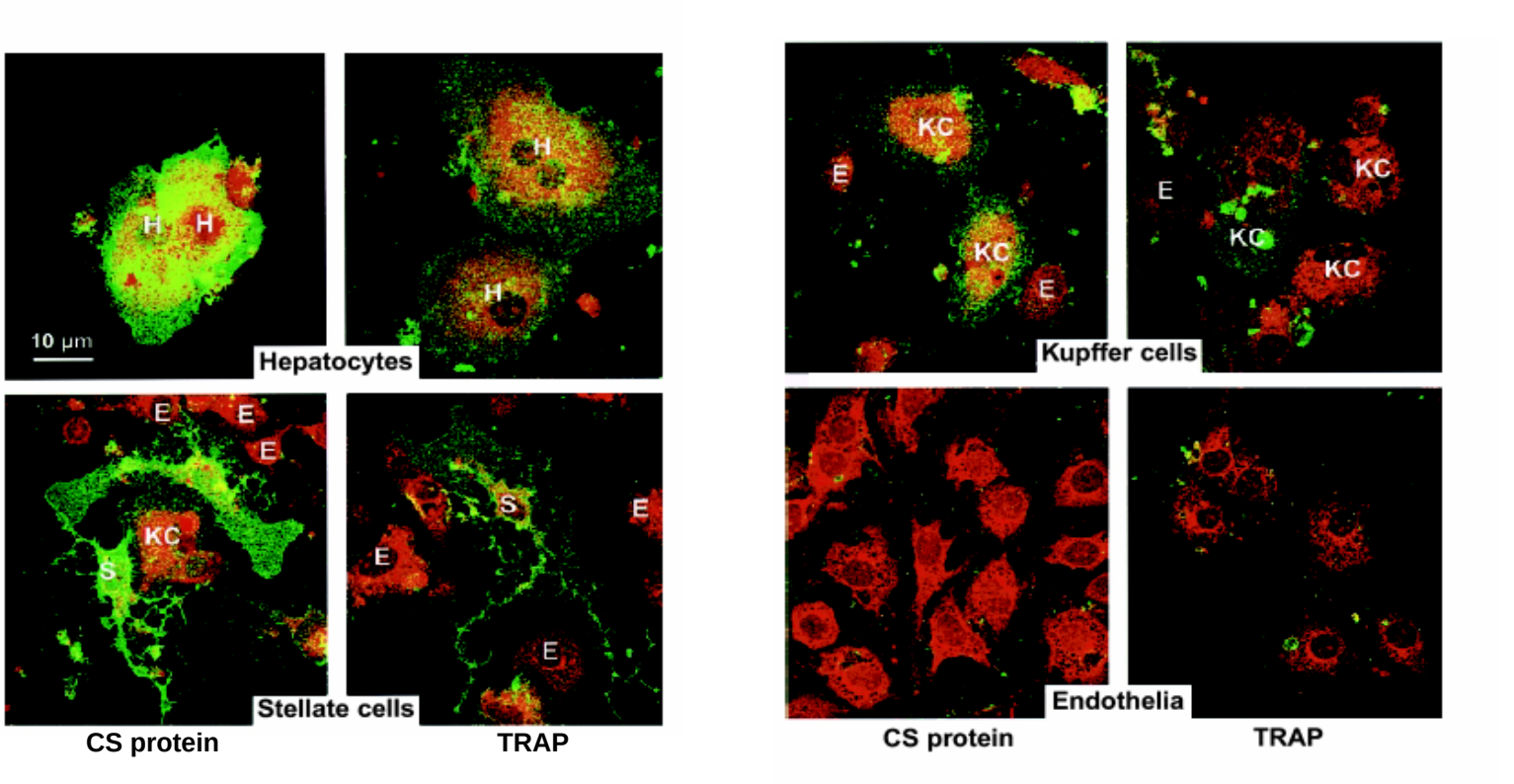
Regulated apical exocytosis is observed as a “cap” in the sporozoite extreme

HepG2



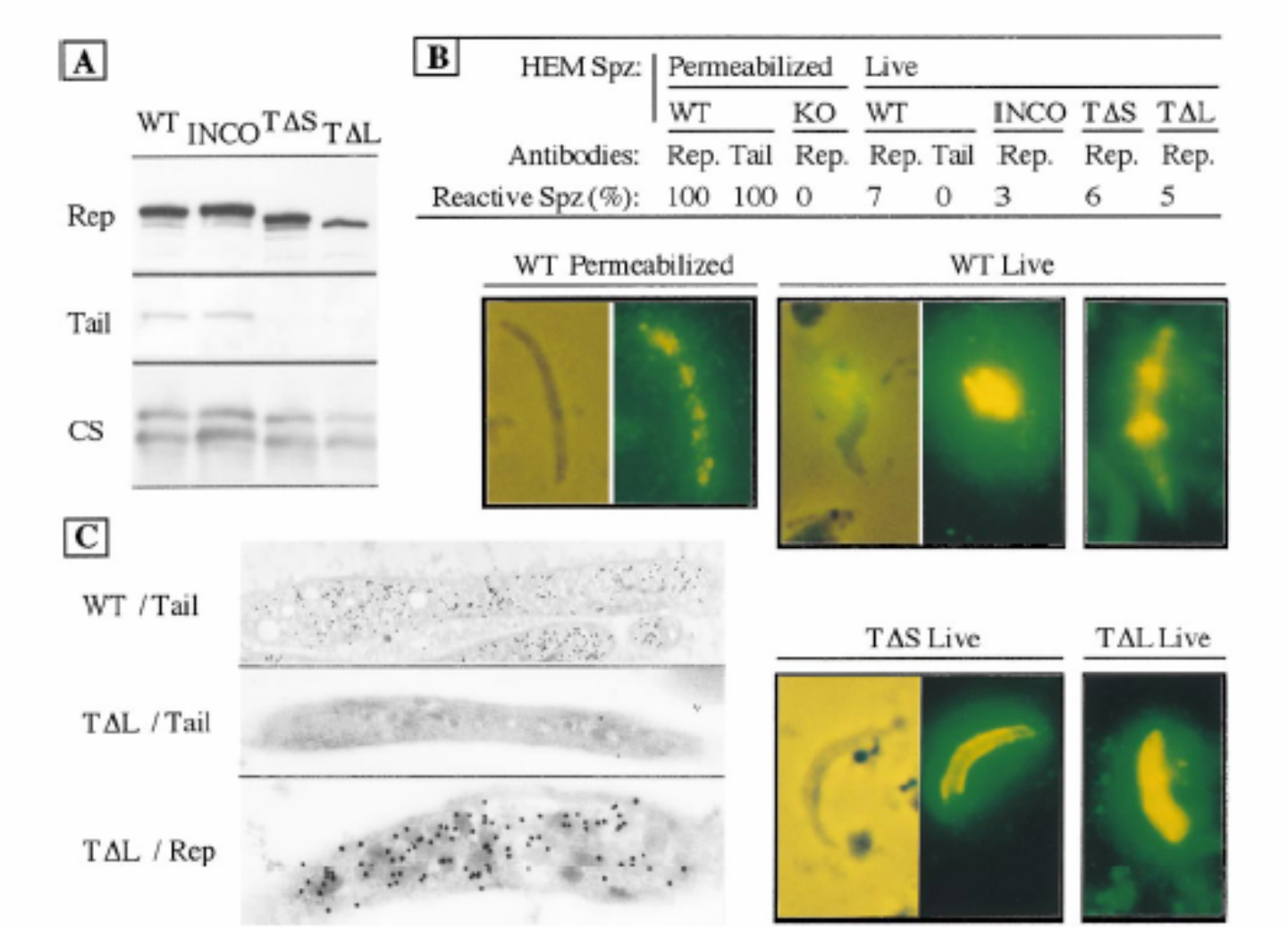
Mota M. *et al*. 2002 **Nature Med** 11:1318

CS and TRAP proteins recognise stellate cells, Kupffer cells and hepatocytes but not endothelium cells' sinuosity



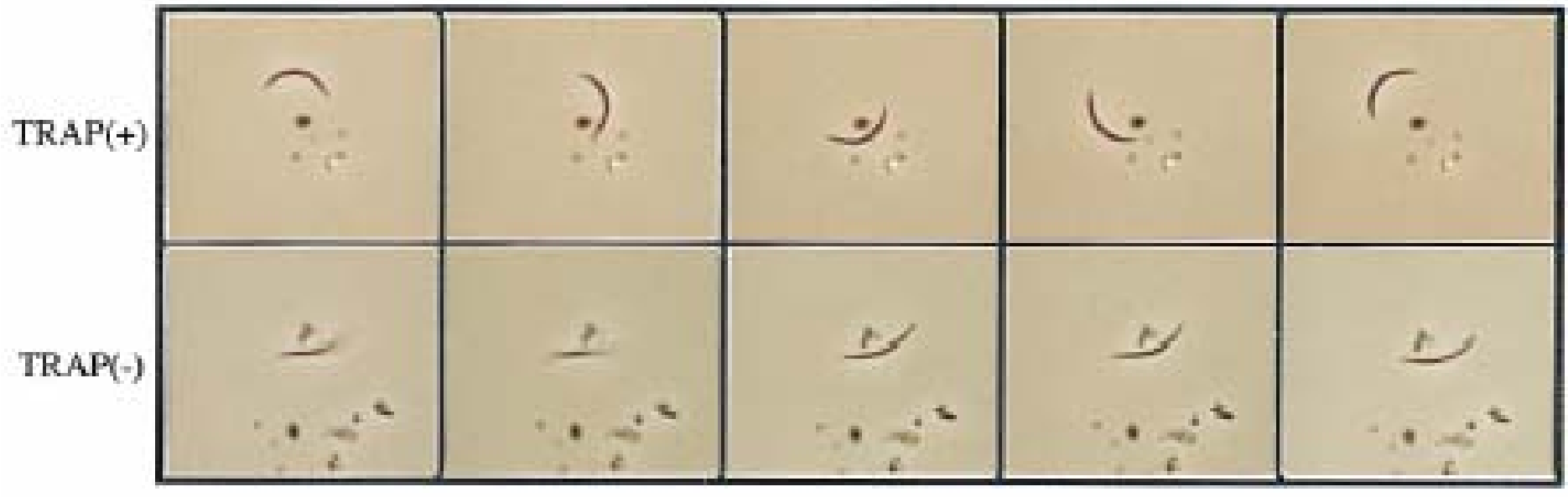
Pradel G. *et al*. 2002 **Mol. Microbiol**. 45: 637

Truncated TRAPs are correctly expressed and found on the sporozoite surface



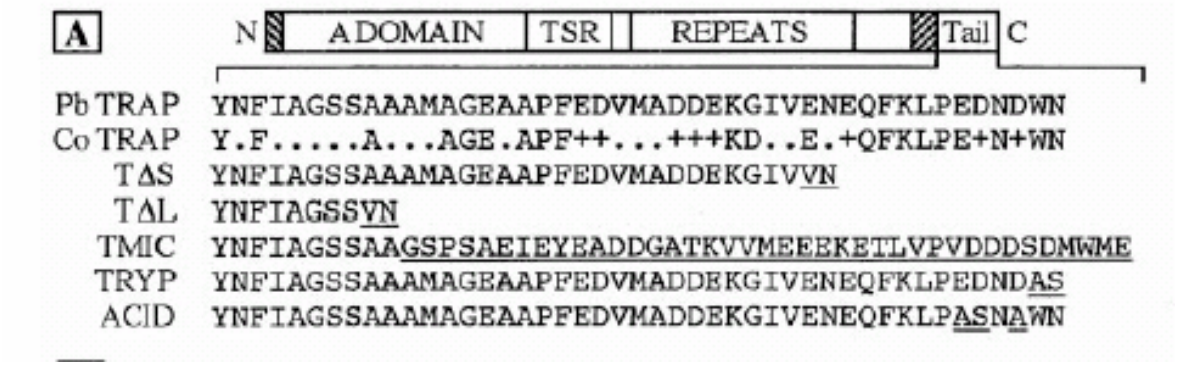
Kappe S. *et al*. 1999 **J Cell Biol.** 147: 937

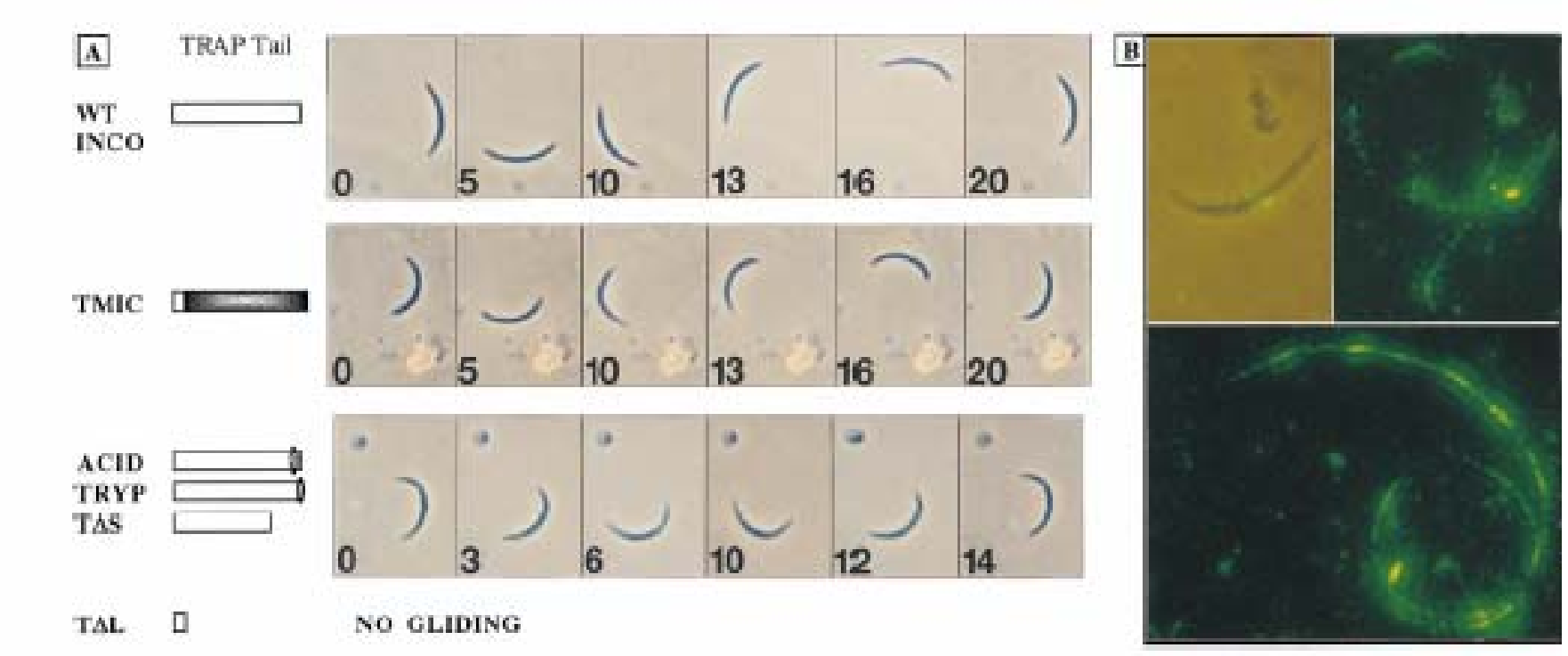
TRAP(-) sporozoite does not express *in vitro* displacement and mobility



Sultan A.A. *et al*. **199**7 Cell, 90: 511

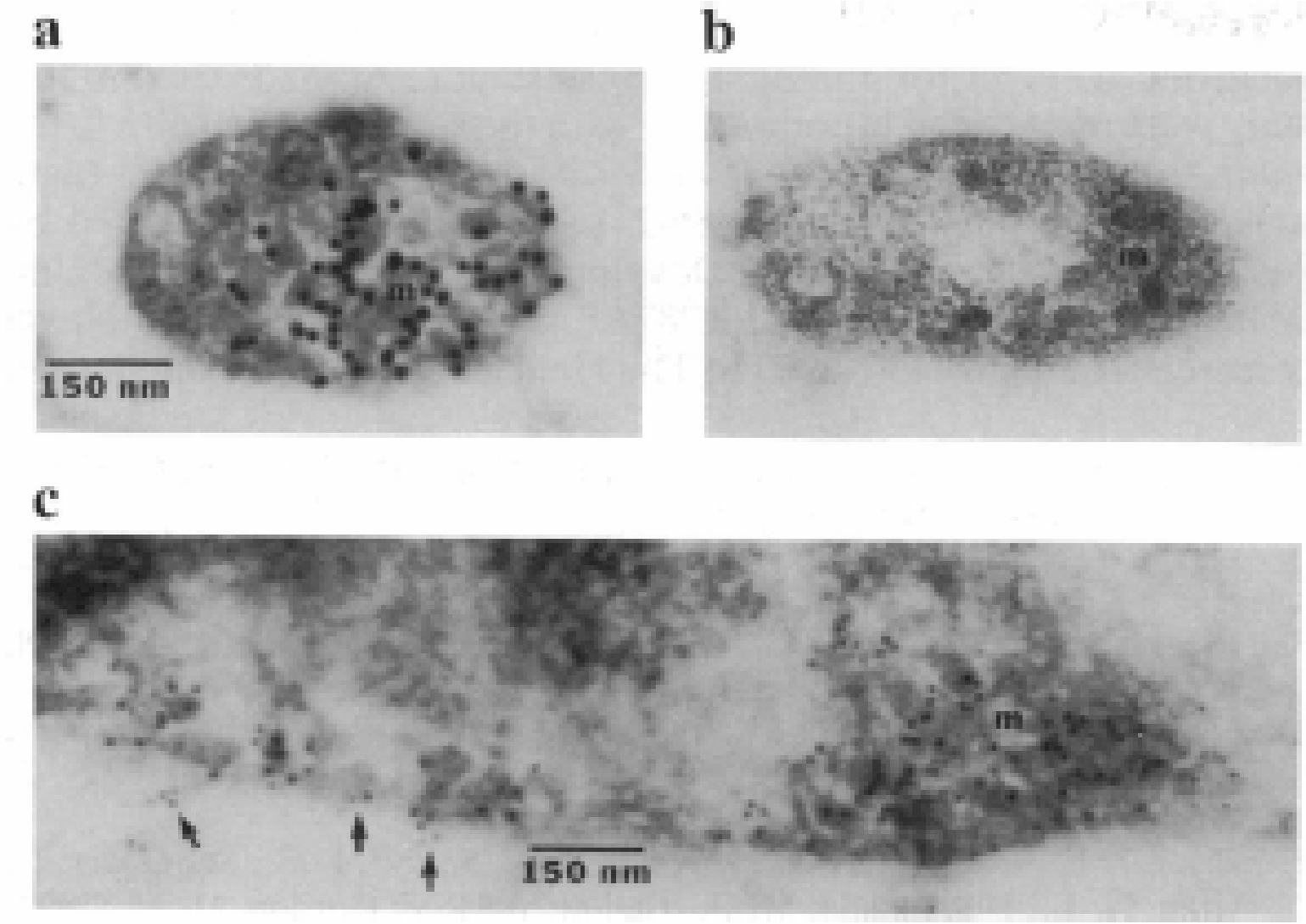
Phenotypical displacement of wild and mutated sporozoites





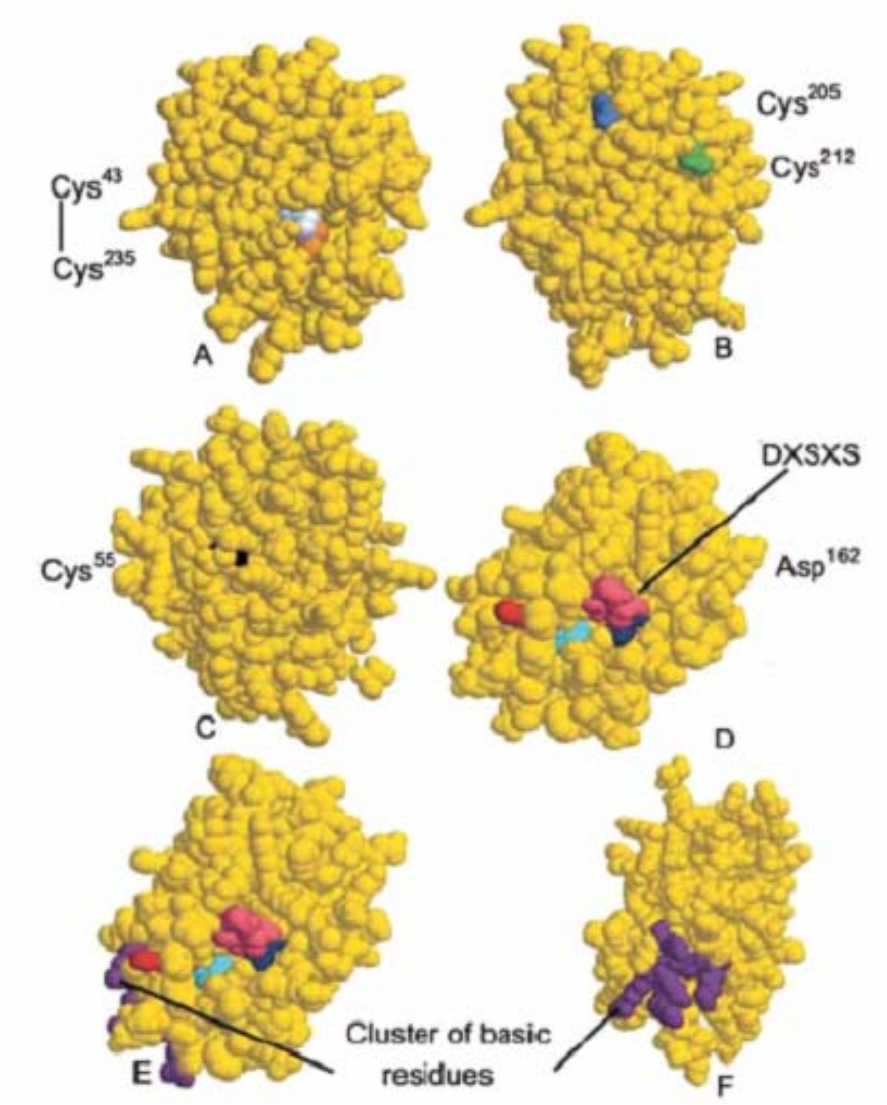
Kappe S. *et al*. 1999 **J Cell Biol.** 147: 937

Immuno-electron microscopy of *P. falciparum* SSP2



Rogers O. W**.** *et al*. 1992 **PNAS** 89 : 9176

Homology modelling based von Willenbrand factor and TRAP A domain



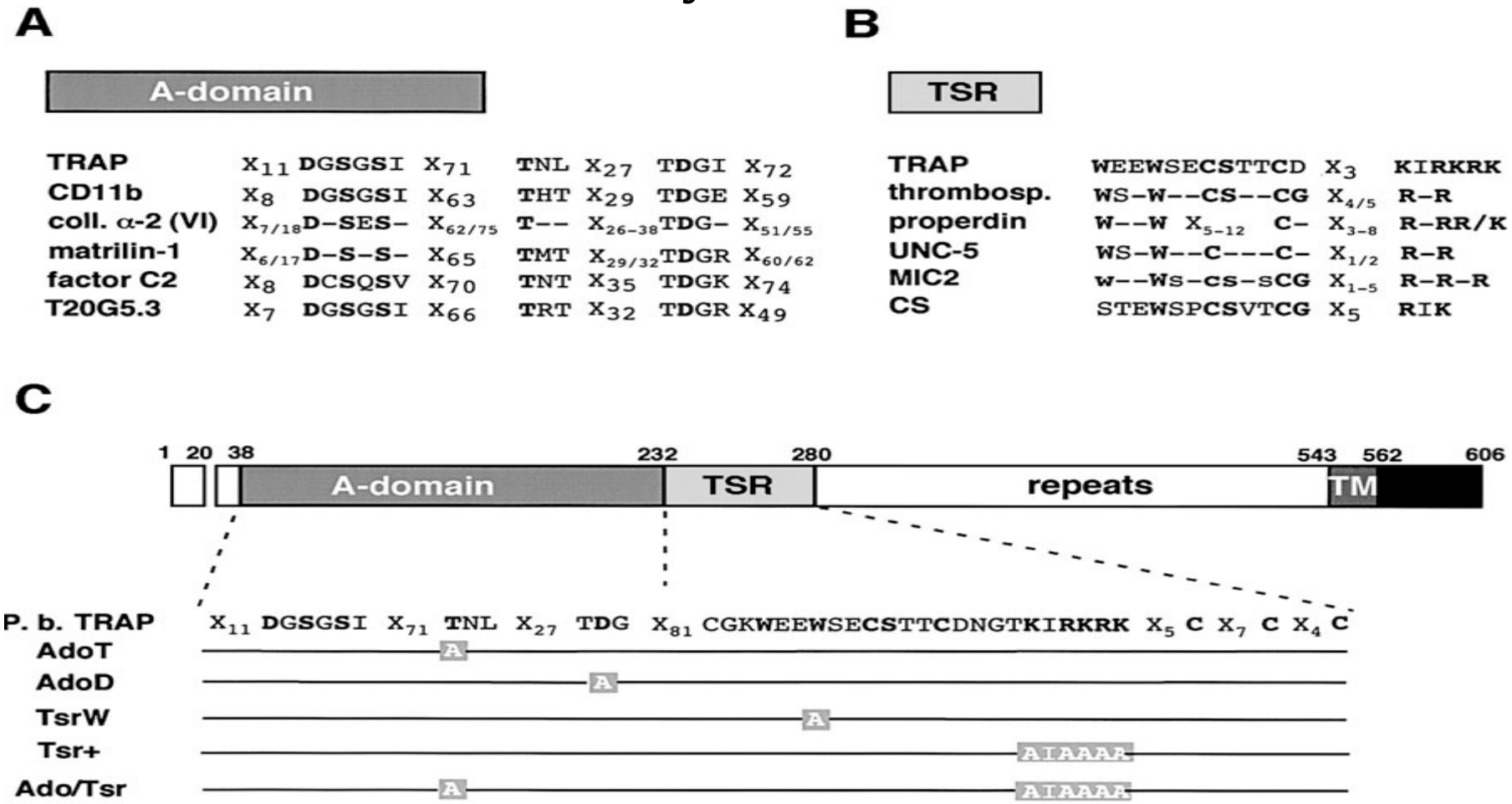
(Mg^{++})

$R^{131}T$-L^{133}

Heparin binding

Akhouri R.R. *et al*. 2004 **J**. **Biochem.** 379: 815

Plasmodium sporozoite invasion of insect and mammalian cells is directed by the same dual binding system

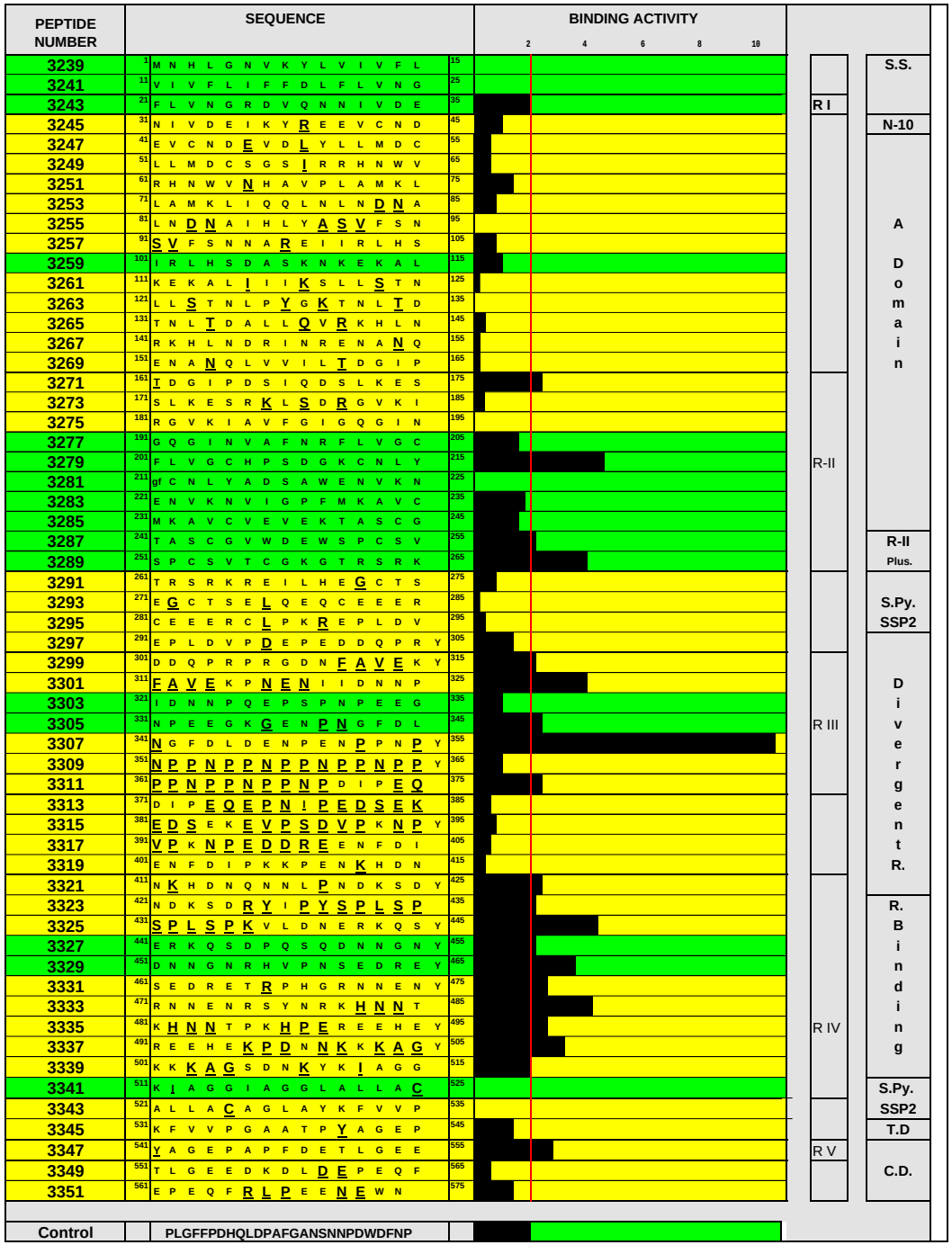


Matuschewski *et al.* 2002 **EMBO J.** 21:1597

Plasmodium falciparum: binding studies of peptide derived from the sporozoite surface protein 2 to Hep G2 cells

R. López
H. Curtidor
M. Urquiza
J. Garcia
A. Puentes
J. Suarez
M. Ocampo
R. Vera
L.E. Rodriguez
F. Castillo
G. Cifuentes
M.E. Patarroyo

2001**, J. Pept. Res**, 58: 285



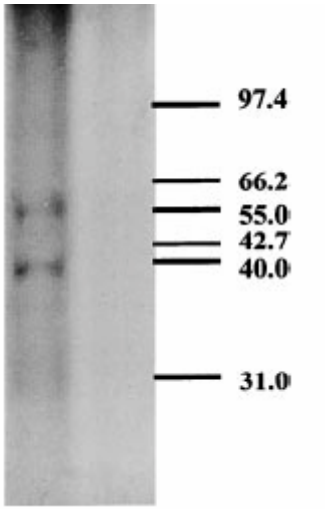
P. falciparum high binding SSP2 peptides containing B epitopes in their sequences

López R. *et al.* 2001**, J. Pept. Res**, 58: 285

Table 2. **Pf SSP2/TRAP peptide affinity constants and critical residue binding to cell Hep G2 cells**

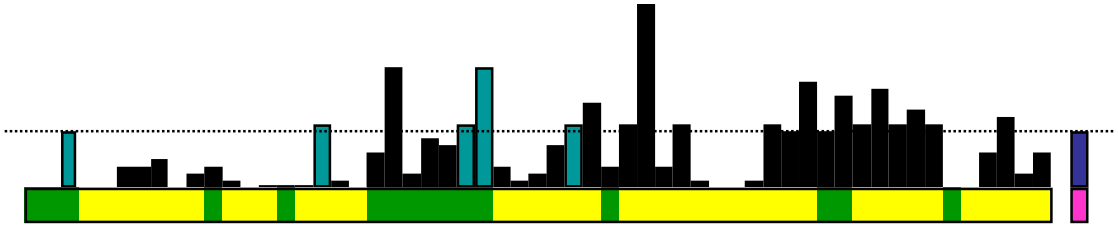
Peptide	Amino acids	Sequence	*Kd* (nM)	NrSC[a]	Hill
5873	19–41	DLFLVNGRDVQNNIVDEIKYREE	658 ± 10	340 000 ± 2500	1.7
5877	336–355	KGENPNGFDLDENPENPPNP	301 ± 4	46 000 ± 1000	1.2
5885	461–485	SEDRETRPHGRNNENRSYNRKHNNT	585 ± 5	490 000 ± 7000	1.3
6481	478–498	YNRKHNNTPKHPEREEHEKPD	543 ± 7	570 000 ± 4000	1.5
5897	490–510	REEHEKPDNNKKKAGSDNKY	457 ± 8	220 000 ± 8000	1.3
5891	535–555	GAATPYAGEPAPFDETLGEE	685 ± 3	770 000 ± 1000	1.1

a. NrSC, number of binding sites per cell. b. Mean±SD of three experiments. The critical residue is underlined.



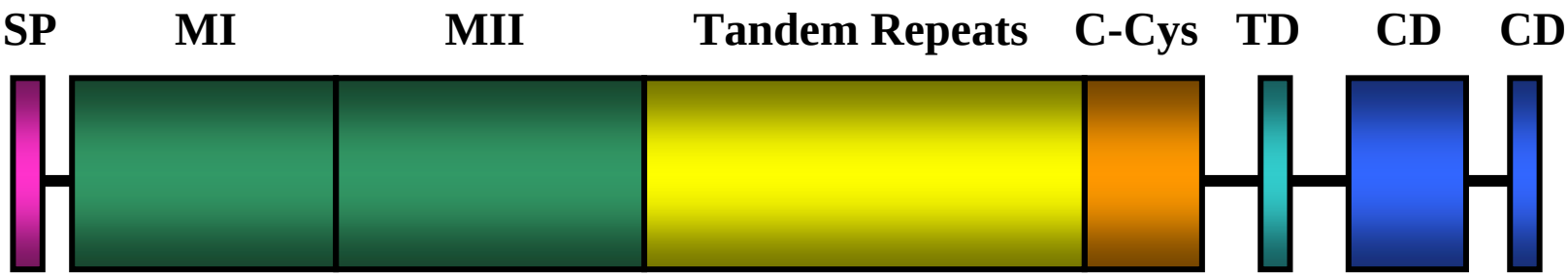
P. falciparum high binding SSP2 peptides containing B epitopes in their sequences

López R. *et al.* 2001**, J. Pept. Res**, 58: 285



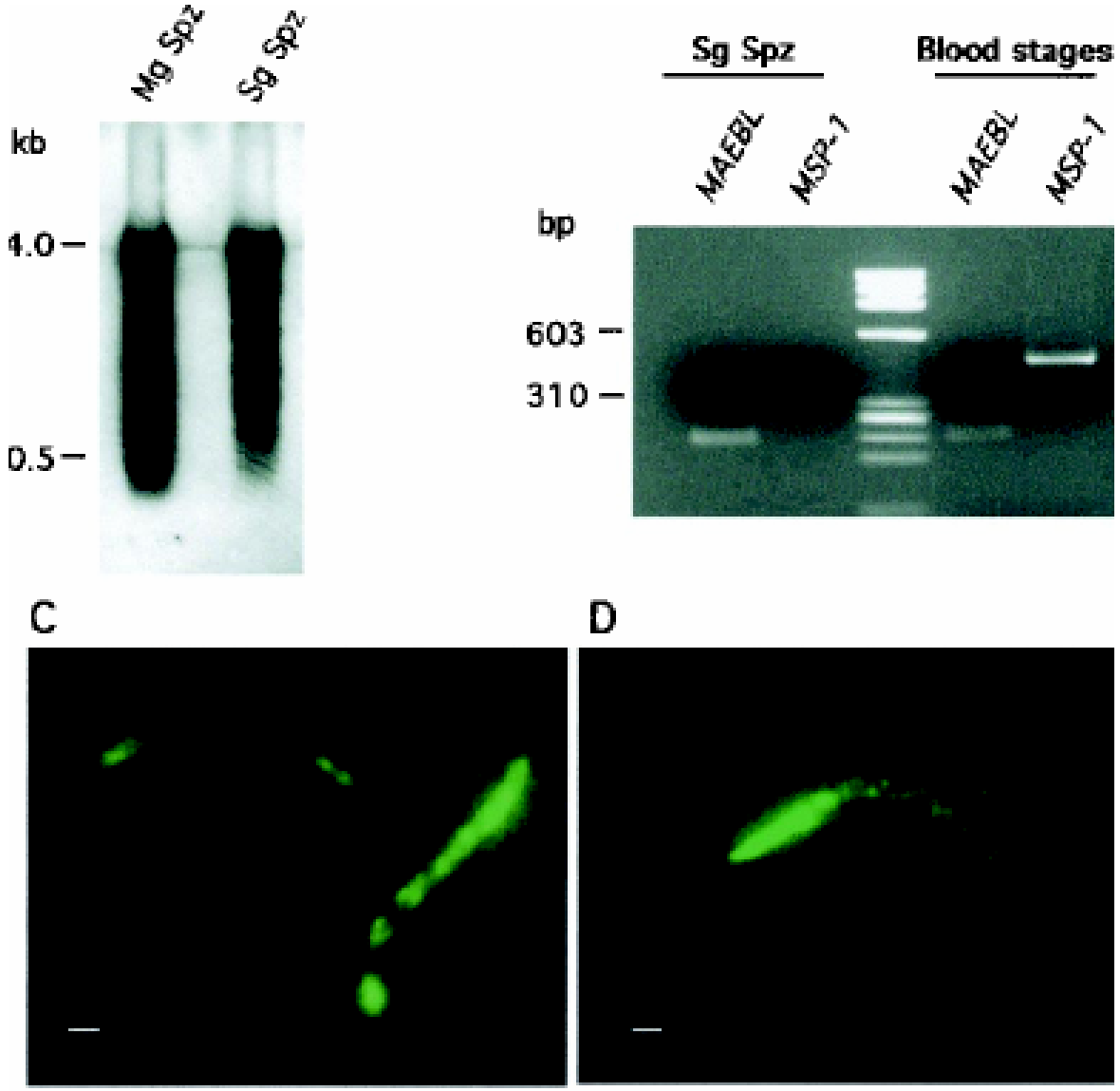
Peptide	amino acids	sequence
3243	(21-35)	FLVNGRDVQNNIVDE
5873	(19-41)	DLFLVNGRDVQNNIVDEIKYREEYCND
		S- S
3287	(241-265)	TASCGVWDEWSPCSVTCGKGTRSR
3279	(201-215)	FLVGCHPSDGKCNLY
3299	(298-313)	DDQPRPRGDNFAVEKP
3323	(417-431)	NDKSDRYIPYSPLSP
5885	(456-485)	SEDRETRPHGRNNENRSYNRKHNNT

Apical Membrane Antigen/Erythrocyte Binding-Like Protein (MAEBL)(243 kDa)



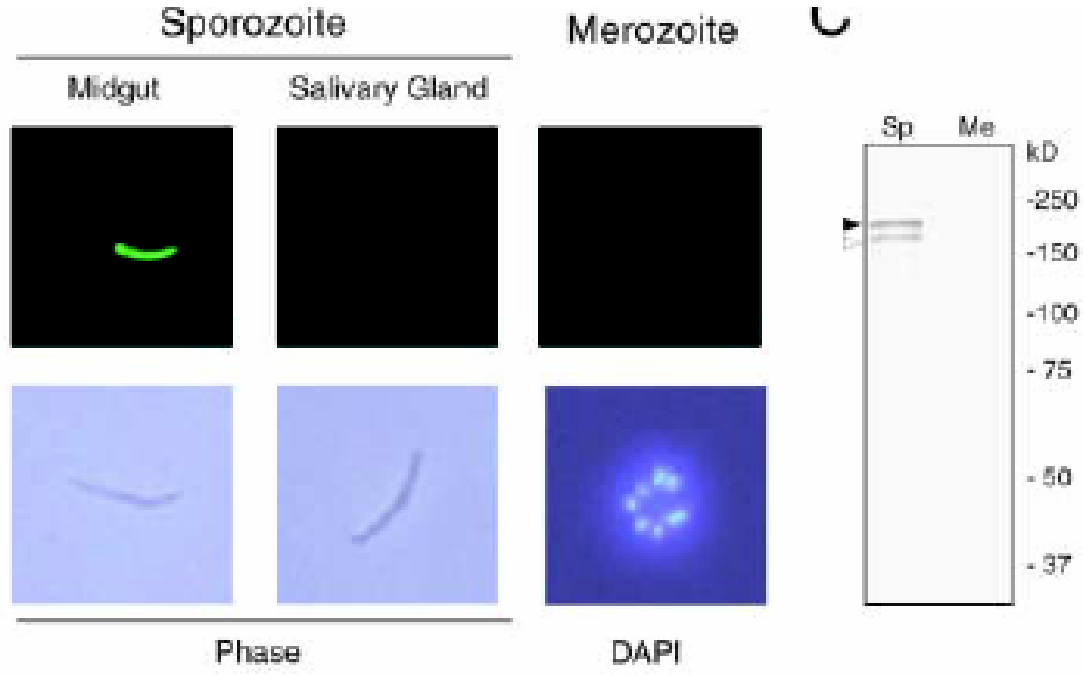
Kappe S et al, 2003, **Trends Parasitol**. 19:135

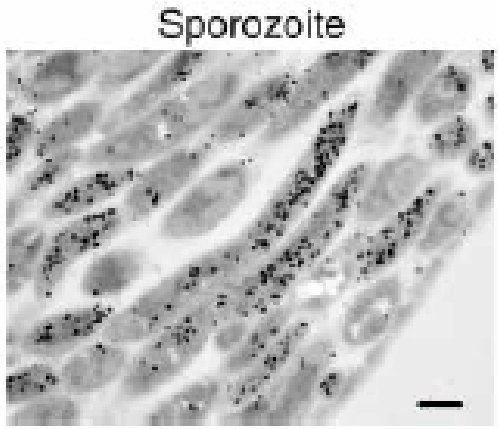
MAEBL sporozoite expression

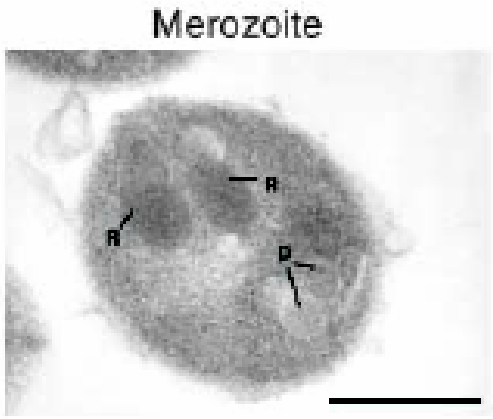


Kappe S. *et al*, **2001 PNAS**, 98: 9895

PbMAEBL stage-specific production and localisation in micronemes

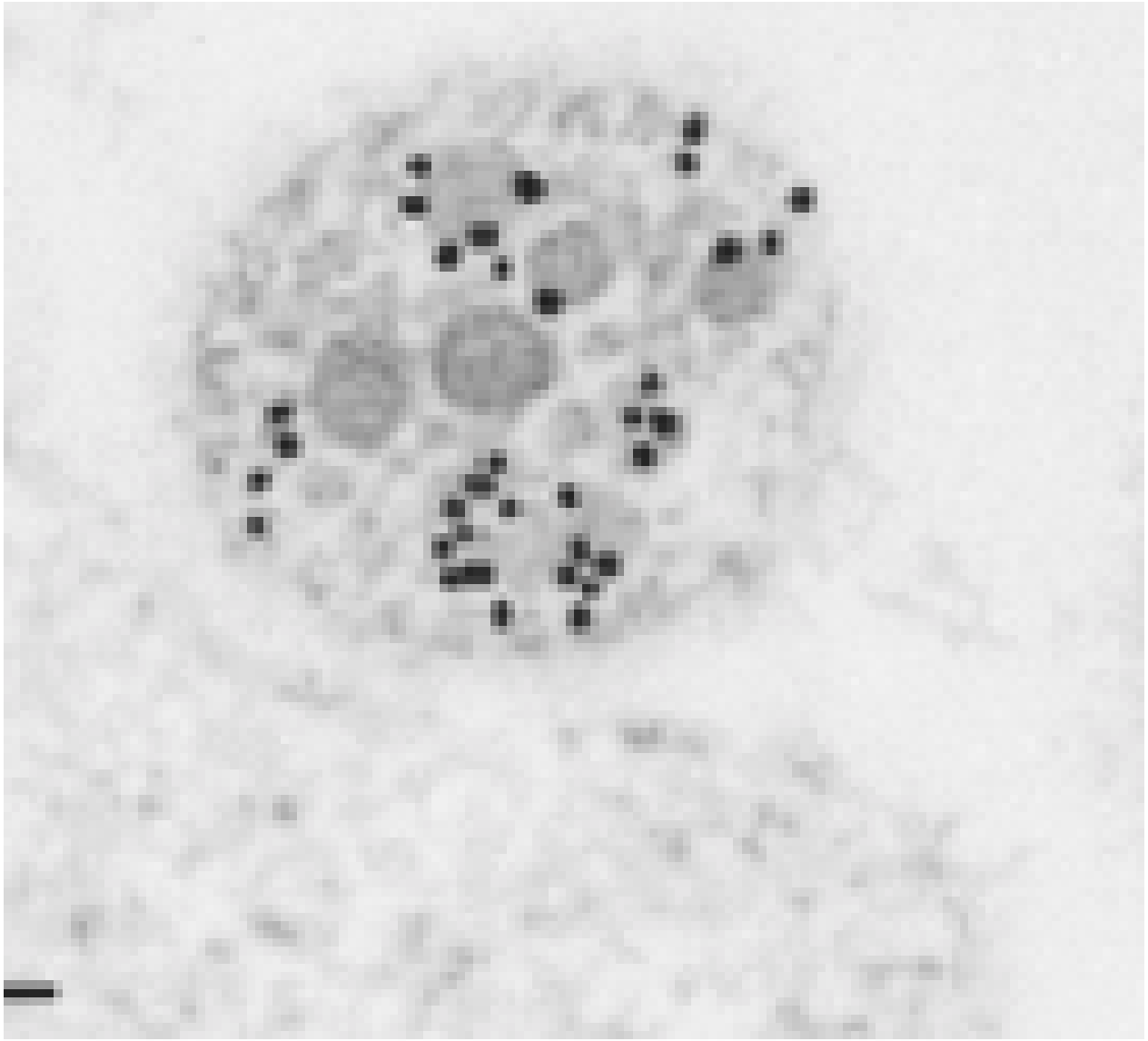






Karin T. *et al*. 2002 **J. Exp. Med**.,195:1317

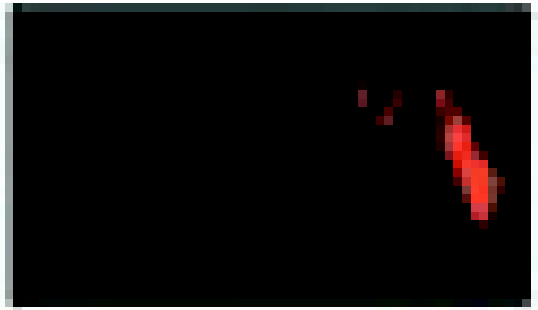
Labelling an oocyst sporozoite section with anti-MAEBL antibodies reveals micronemal localisation



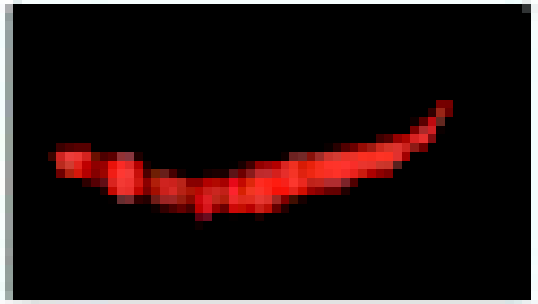
Kappe S et al, 2003, **Trends Parasitol**. 19:135

Differential localisation of *P. Berghei* MAEBL salivary gland sporozoites

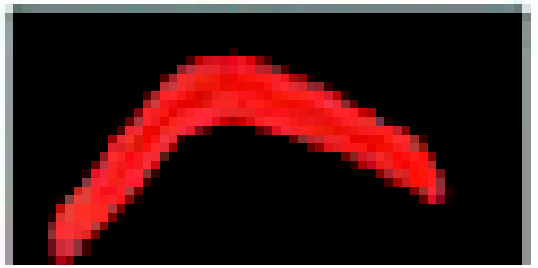
MG D15 sporozoite



MG D22 sporozoite



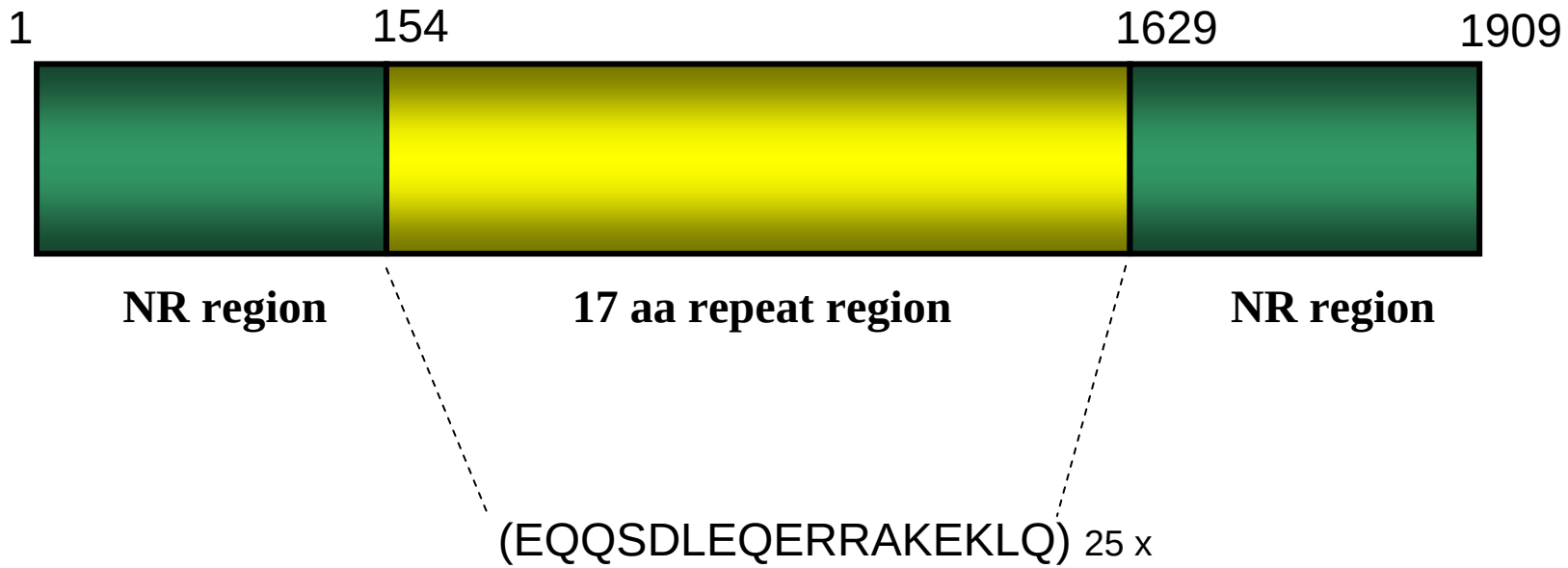
MG D25 sporozoite



Prakash S, *et al*, 2004 **J Biol Chem**, 279:5581

Liver Stage Antigen 1 (LSA-1)

(240 kDa)



Localisation:

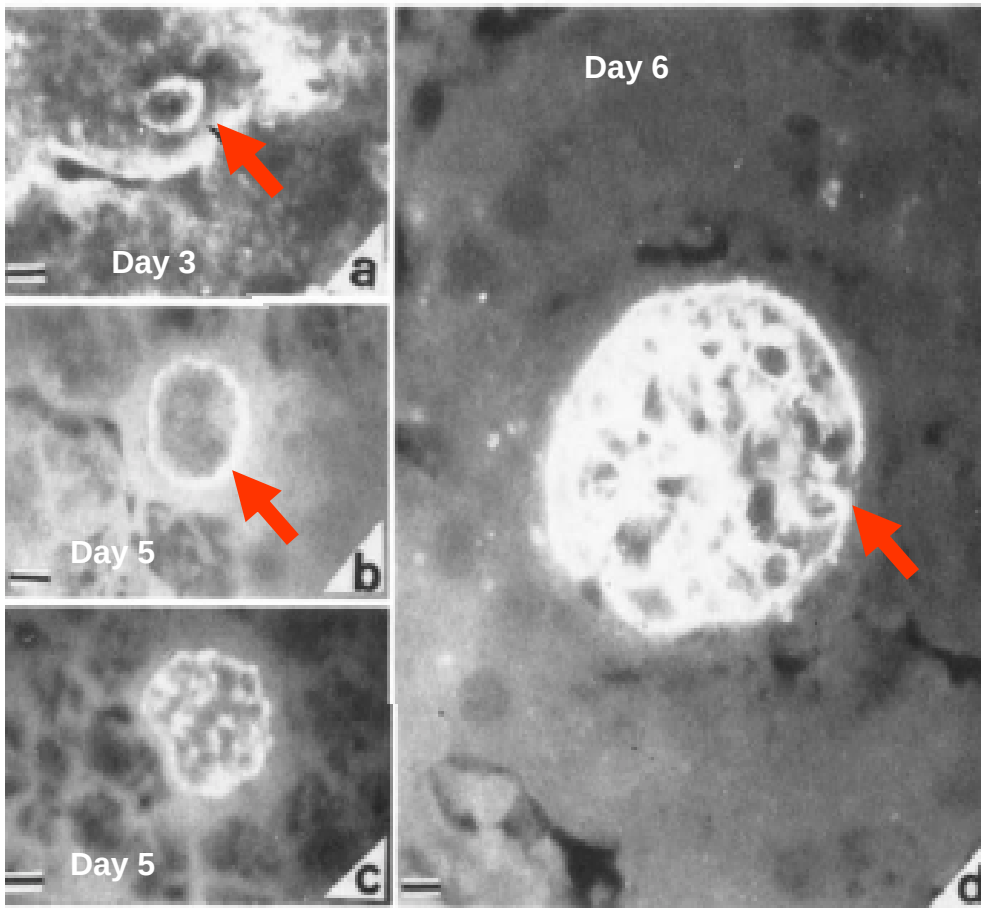
Tpz, PVM, Liver Schz-Mz

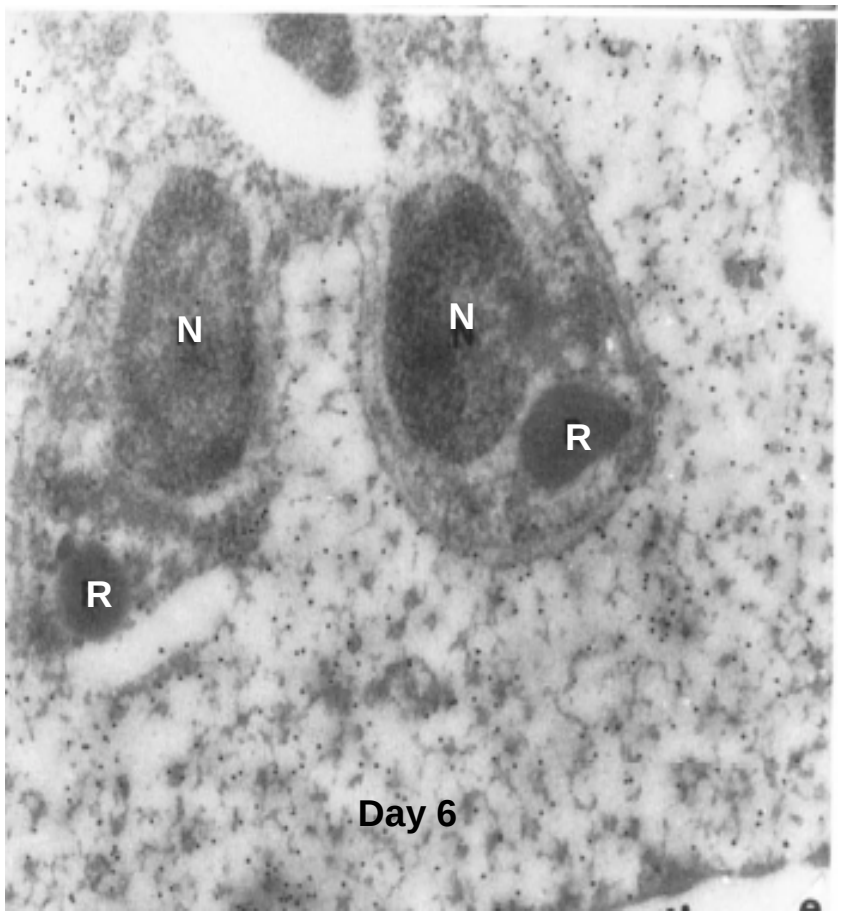
Possible function:

Adhesion, Invasion

Fidock D, et al, 1994, **J Immunol**. 153:190

Localisation of LSA-1 during liver stage schizogony

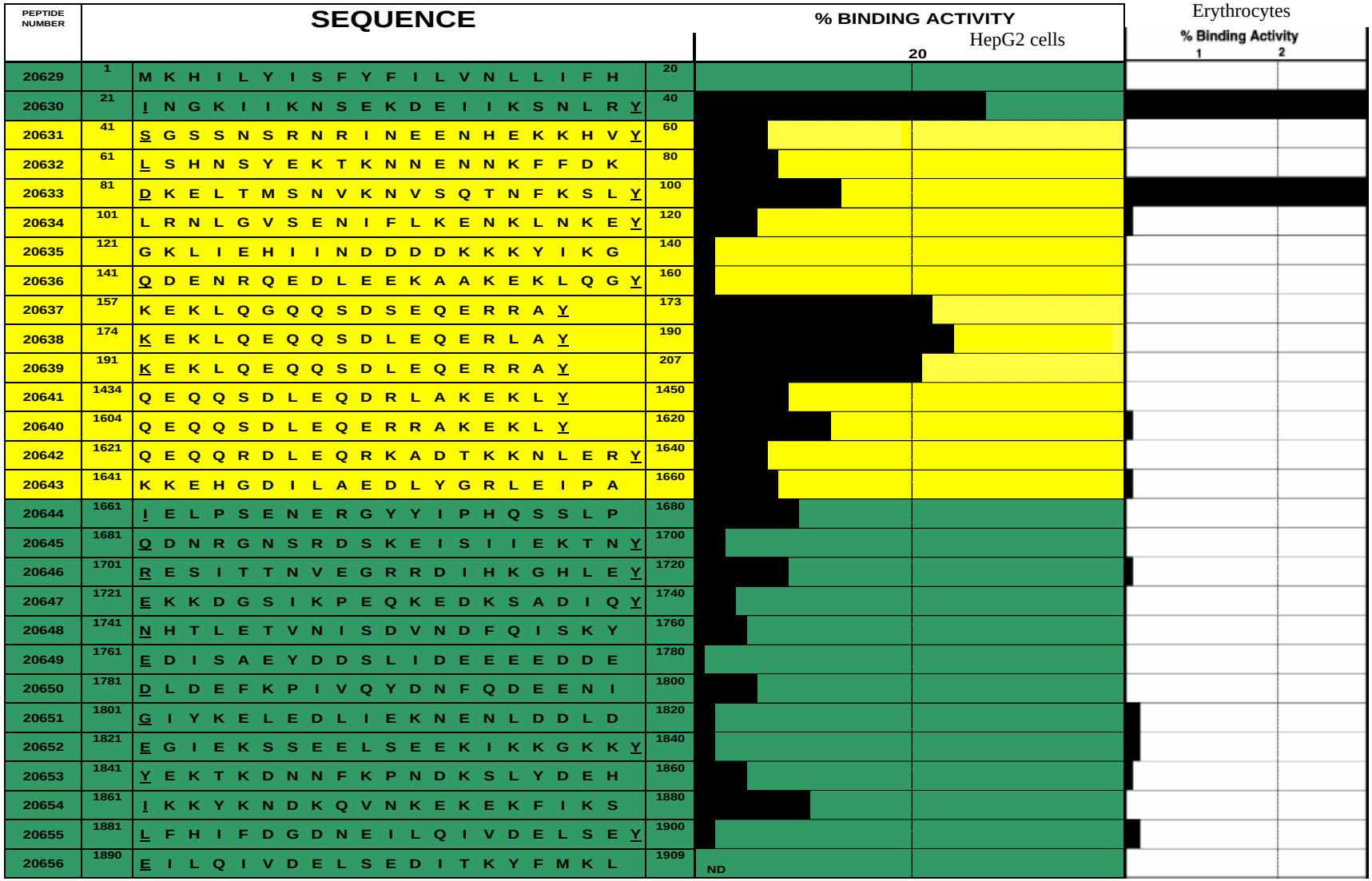




Fidock D, et al, 1994, **J Immunol** 153:190

Peptide of the liver stage antigen-I (LSA-1) of *Plasmodium falciparum* bind to human hepatocytes

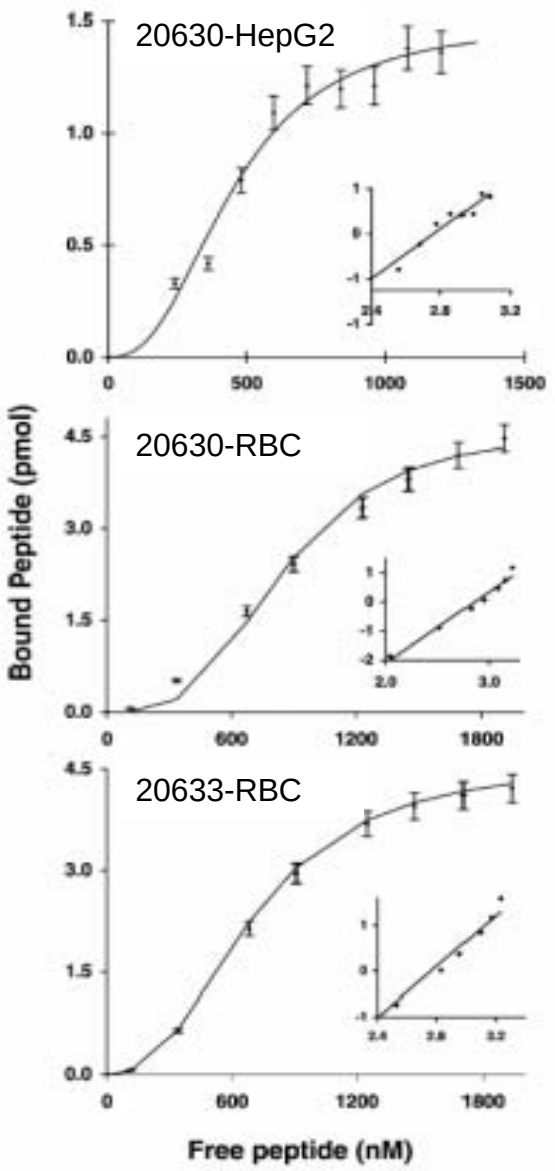
García J. *et al*, 2003, **Peptides,** 24:647



LSA-1 peptides bind to HepG2 and RBC

García J. *et al*, 2003, **Peptides,** 24:647

Saturation assays



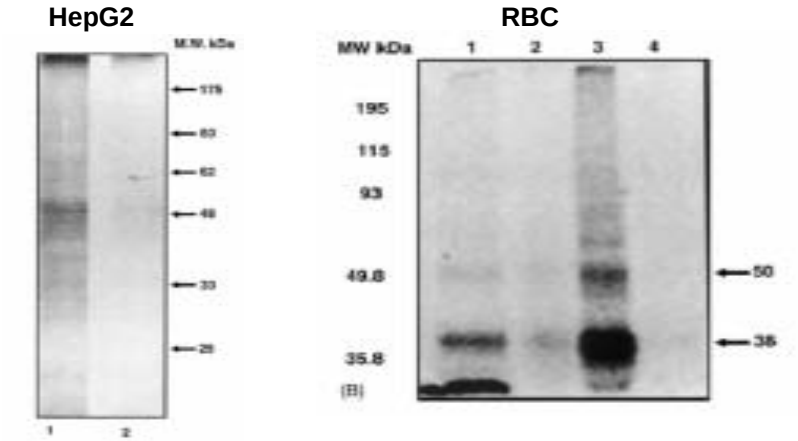
Peptide	K_d (nM)	Sites per cell × 10^6	Hill coefficient
20630[a]	450	0.7	2.0
20630[b]	850	8.3	3.3
20633[b]	700	8.4	2.5

Invasion inhibition

LSA-1 protein high binding peptides and sera analogues invasion and development inhibition assays

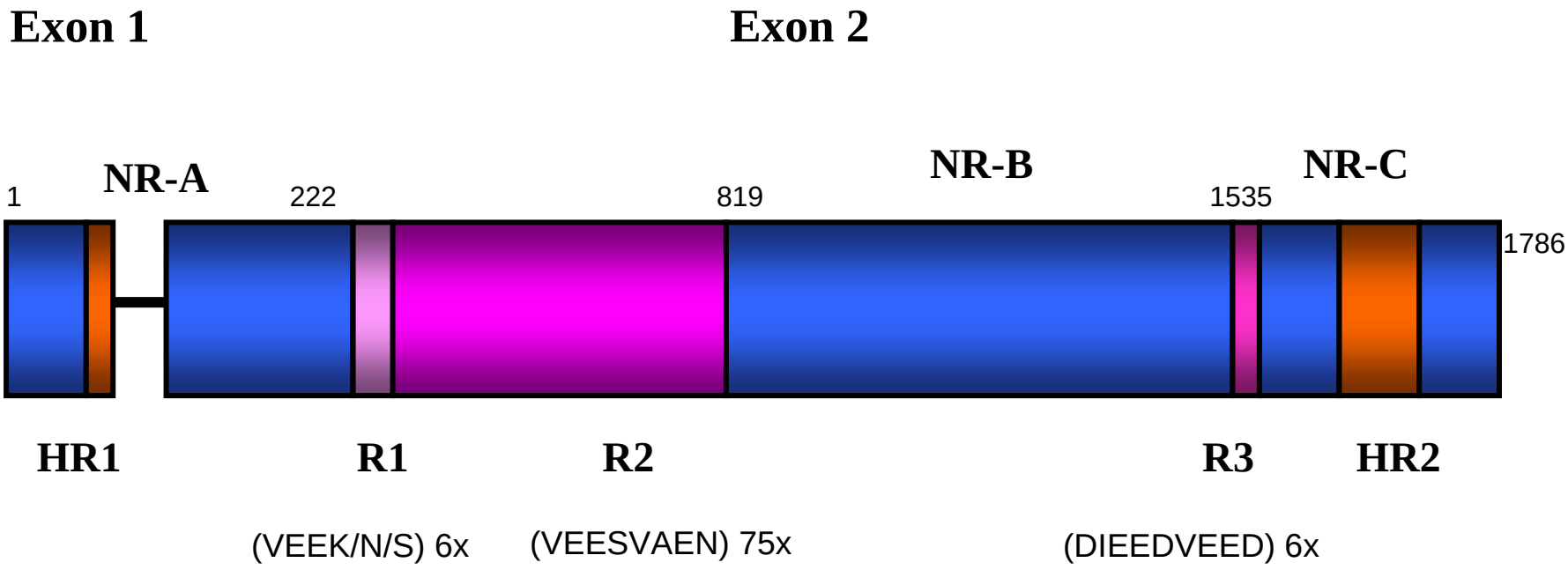
	% Invasion inhibition		% Development inhibition	
	100 μM	200 μM	100 μM	200 μM
Peptide				
20630	10 ± 4	34 ± 2	0 ± 3	0 ± 3
20633	48 ± 1	88 ± 1	15 ± 4	85 ± 1
6762	13 ± 2	100 ± 2	0 ± 5	57 ± 2
Chloroquine	100 ± 2	100 ± 2	100 ± 2	100 ± 2

Cell membrane assay



Liver Stage Antigen 3 (LSA-3)

(200 kDa)



Localisation:

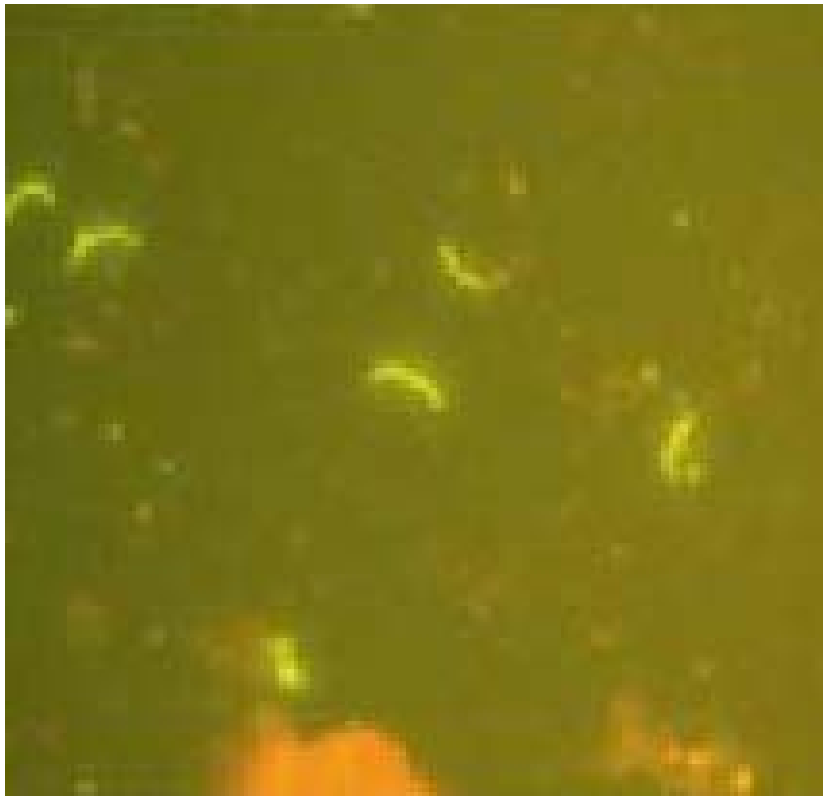
Surface Spz, PV, Liver Stage

Possible function:

Adhesion, Invasion

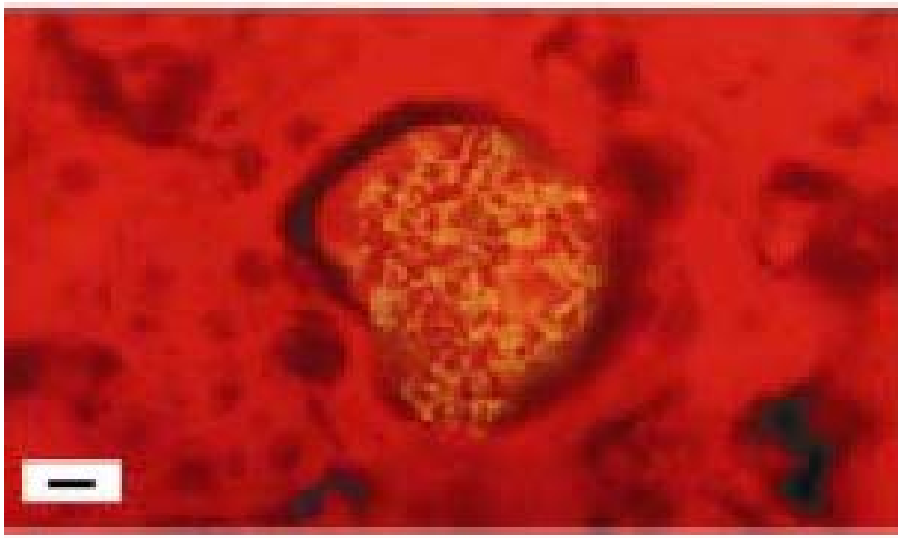
Daubersies P, et al. 2000 **Nat Med** 6:1258

Localisation of LSA-3 in *P. falciparum* sporozoite cytoplasm and membrane

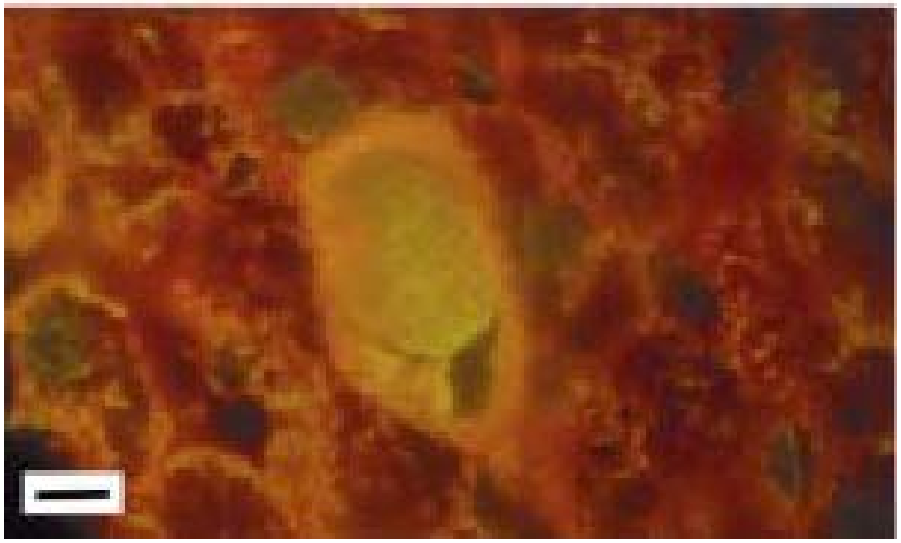


http://www.pasteur.fr/recherche/unites/parmed//lsa3/lsa3si.pdf

LSA-3 appears to be located in liver schizont parasitophorous vacuole

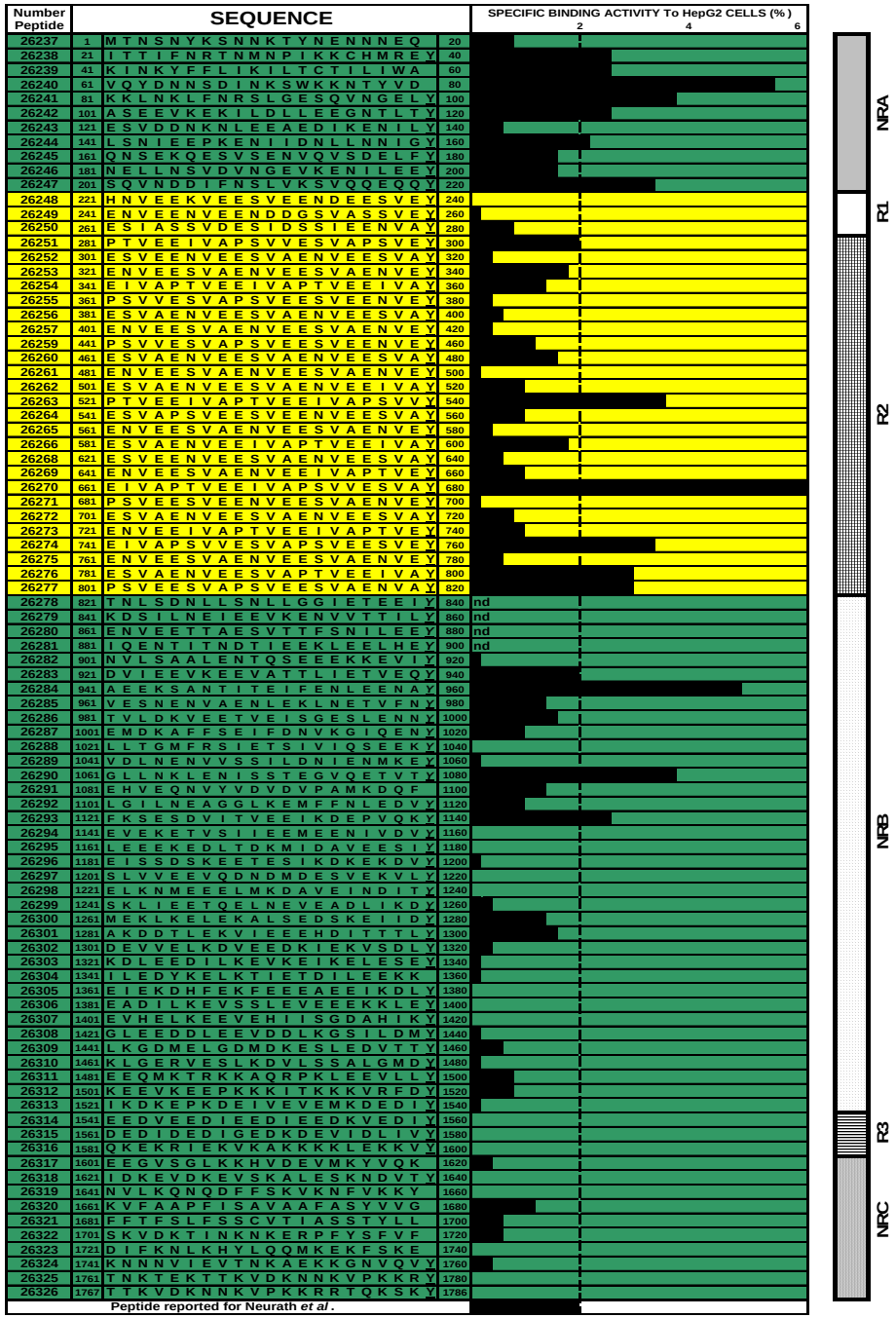


Anti-NRA Schizont (mouse)



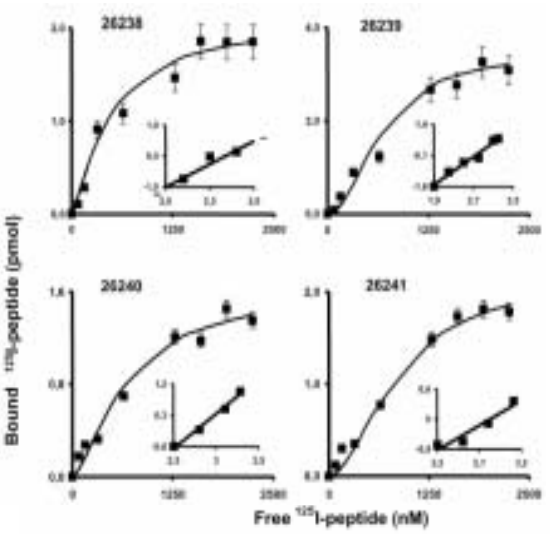
Anti-NRA Schizont (chimpanzee)

http://www.pasteur.fr/recherche/unites/parmed//lsa3/lsa3si.pdf



Liver Stage Antigen 3 *Plasmodium falciparum* peptides specifically interacting with HepG2 cells

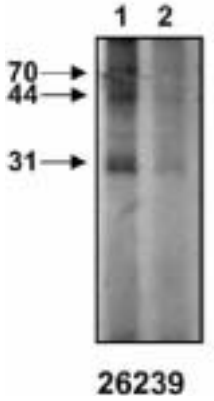
Garcia J. *et al*, 2004, **J Mol Med,** 82:600



Saturation assays

Kd= 480-880 nM

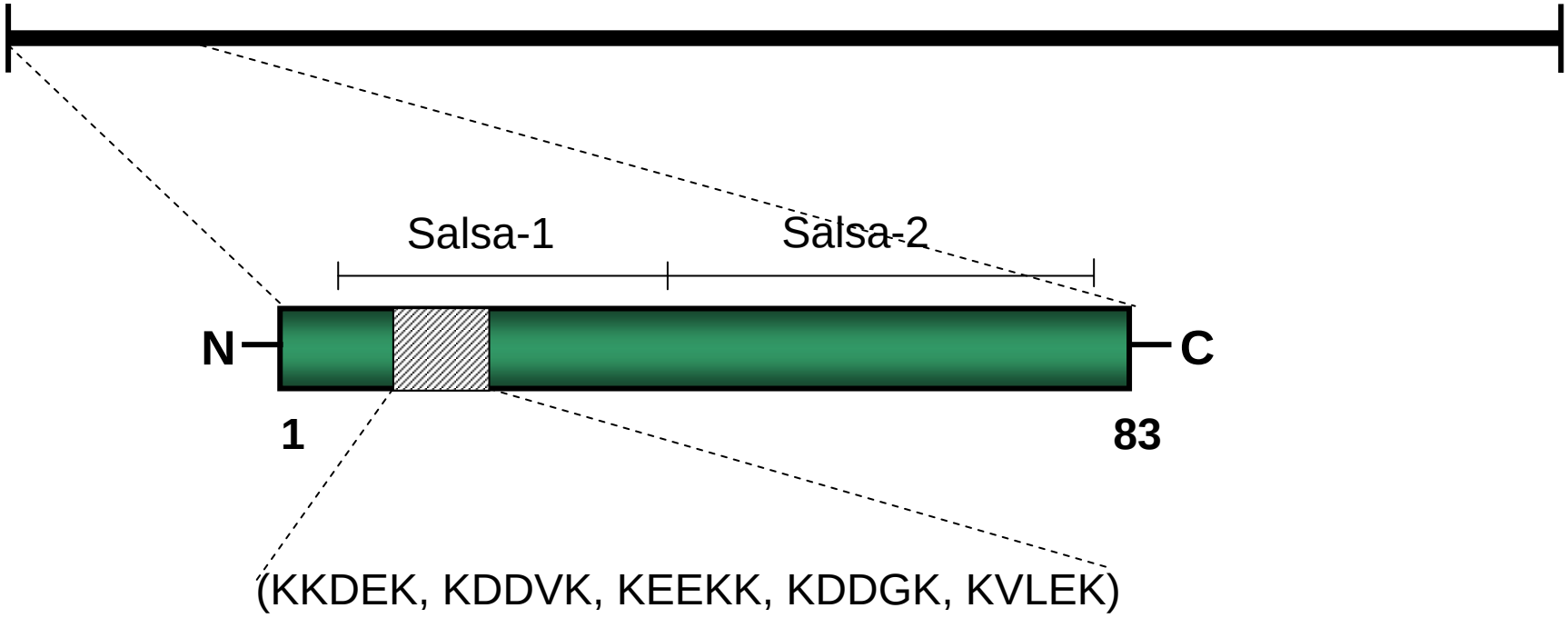
Sities/cell= 0.5-1.5x10^6



HepG2 Cell membrane assay

Sporozoite And Liver Stage Antigen (SALSA)

(70 kDa)



Localisation:

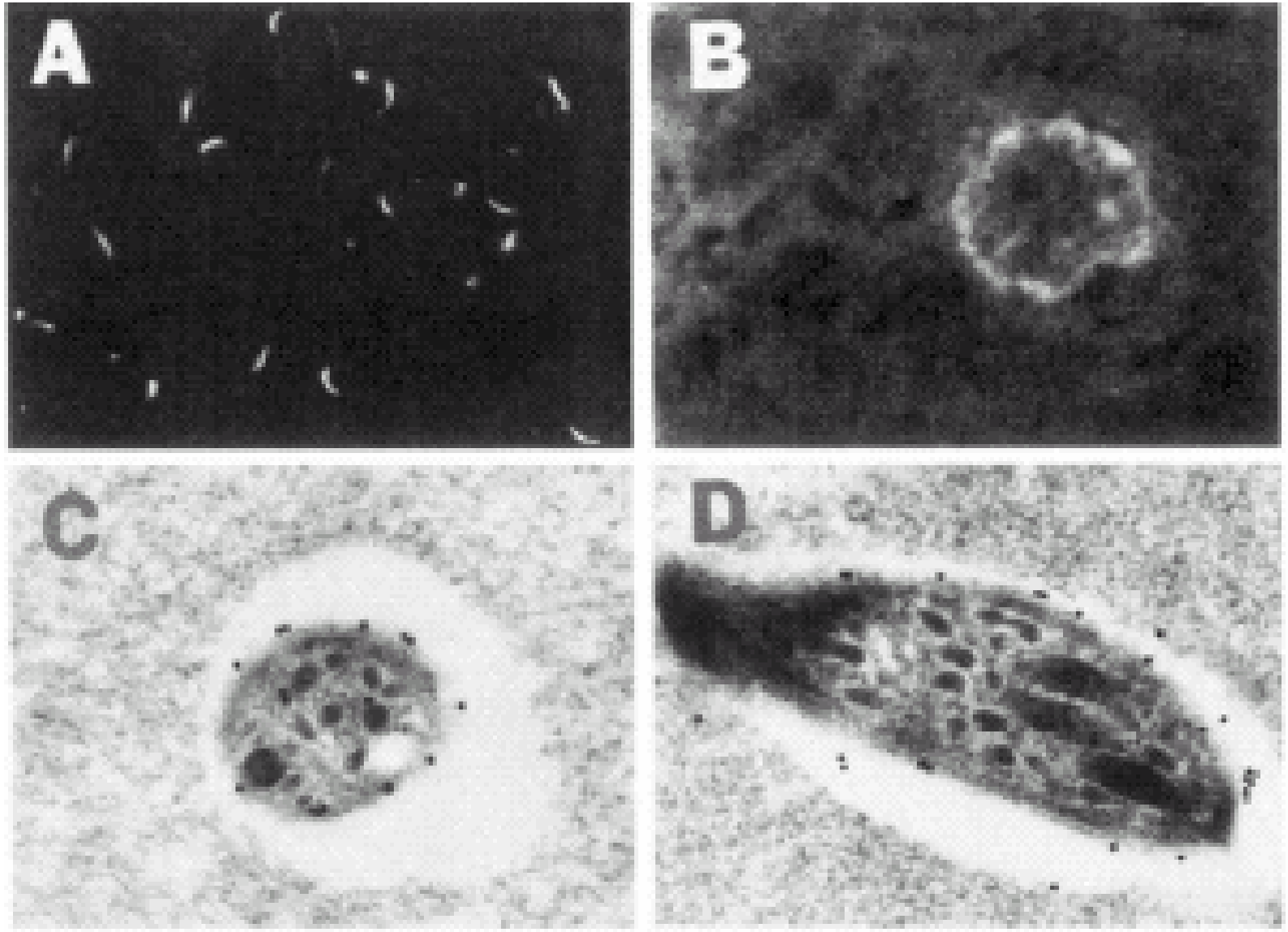
Surface Spz, PV, Liver Stage

Possible function:

Adhesion, Invasion

Bottius E. *et al*. 1996. **J Immunol** 156:2874

Localisation of SALSA in *P. falcarum* sporozoites (A, C and D) and liver stage (B)



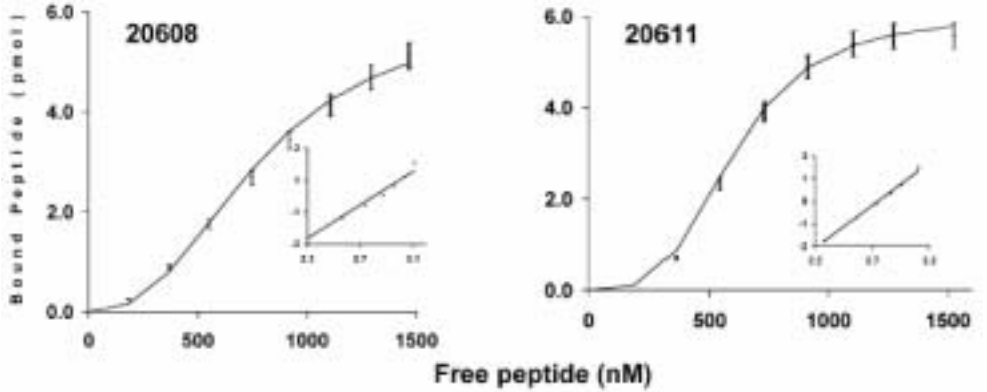
Bottius E. et al. **J Immunol**. 1996 156(8):2874

Sporozoite and Liver Stage Antigen *Plasmodium falciparum* peptides bind specifically to human hepatocytes

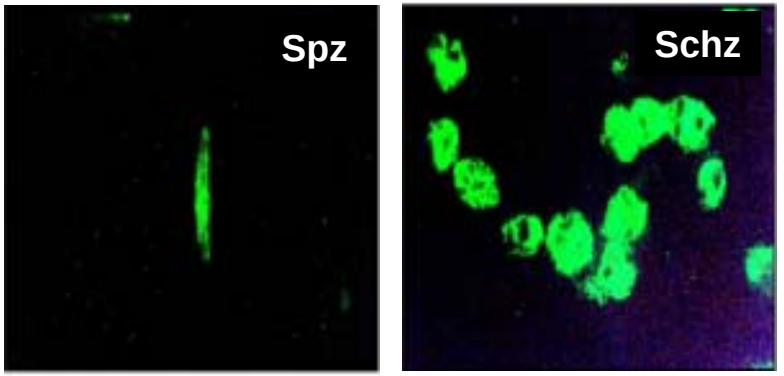
Puentes A, et al, 2004 **Vaccine**, 22:1150

				SLOPE	
PEPTIDE		SEQUENCE		1%	2%
20607	1	RVSTSDTPGGNESSSAFPQFY	20		
20608	21	IWSAEKKDEKEASEQGEESHY	40		
20609	41	KKENSQESANGKDDVKEEKKY	60		
20610	61	TNEKKDDGKTDKVQEKVLEKY	80		
20611	64	KKDDGTDKVQEKVLEKSPKY	83		

Saturation assay

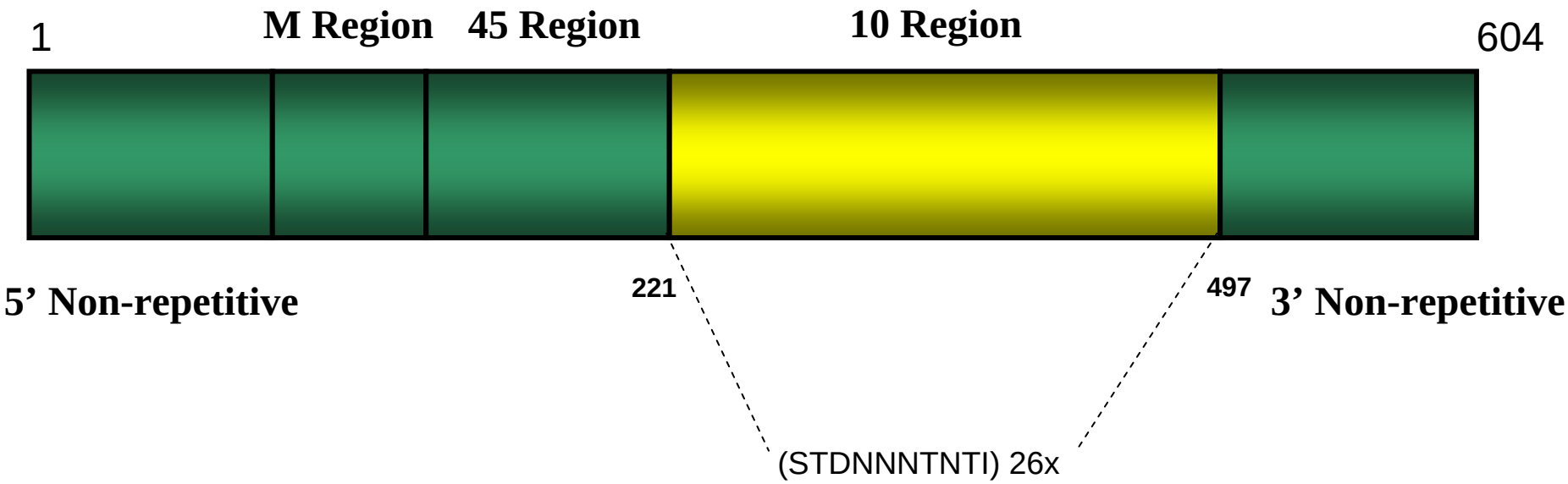


IFA assays



Sporozoite-threonin-asparagine-rich protein (STARP)

(67 kDa)



Localisation:

Surface Spz, Liver Stage, RBC

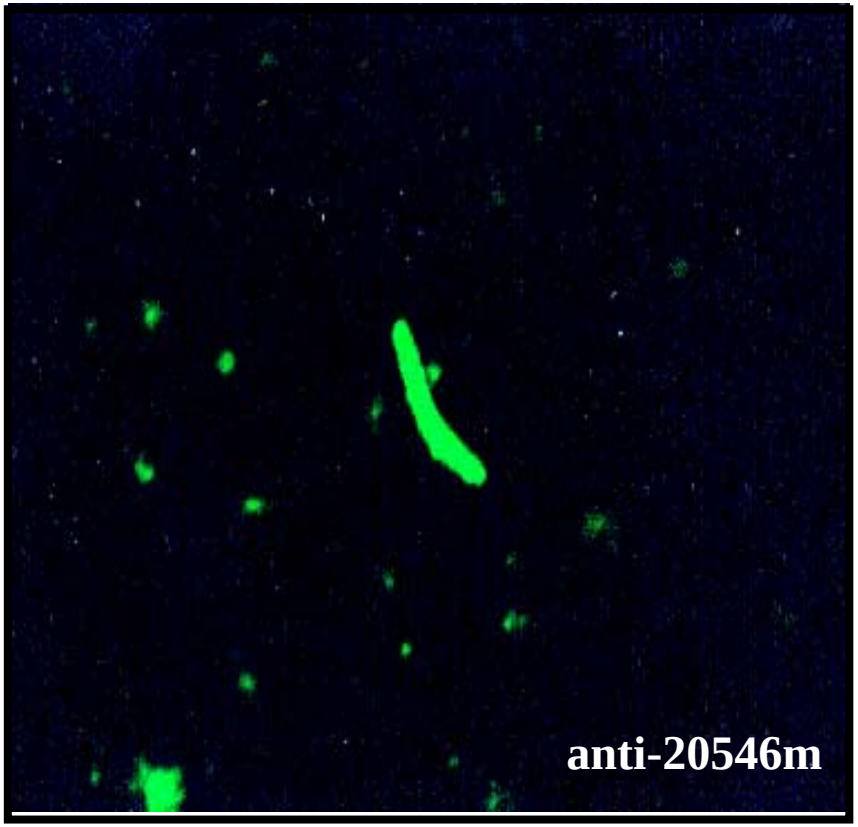
Possible function:

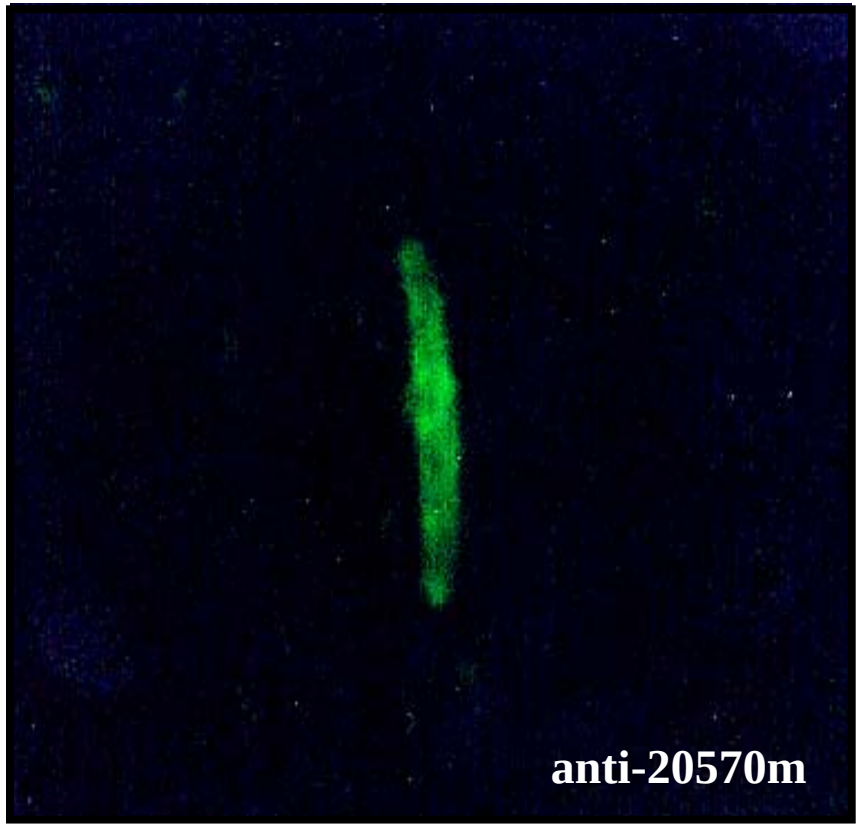
Sporozoite invasion

Fidock DA. Et al. 1997. **Eur J Immunol**. 27:2502

Anti-sporozoite indirect immunofluorescence with *Aotus* monkey sera immunises STARP protein peptide analogues

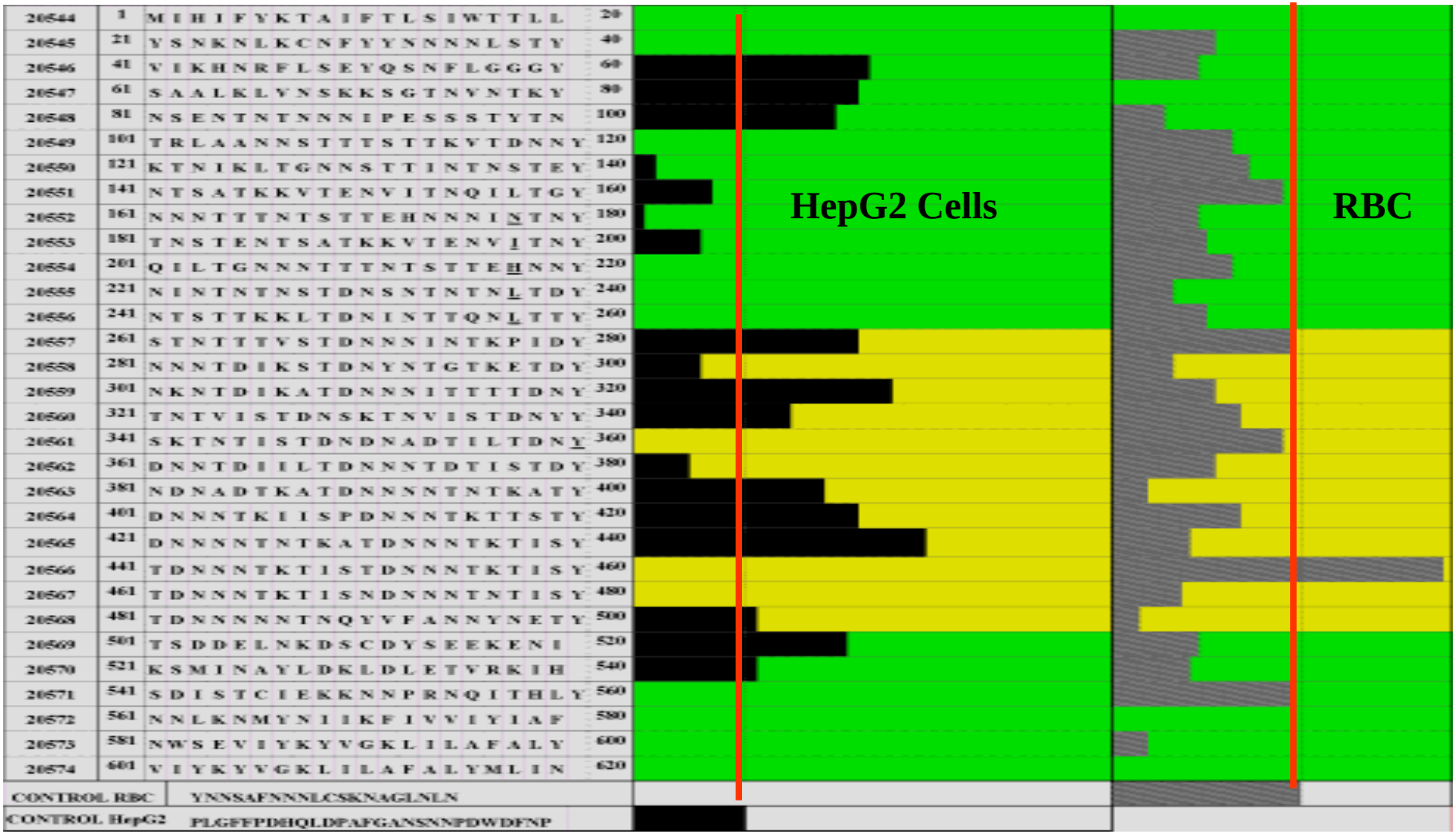
López R. et al, 2003. Vaccine 21:2404





Identification of specific HepG2 cell binding regions in *Plasmodium falciparum* sporozoite-threonine-asparagine-rich protein (STARP)

Lopez, et al, 2003 Vaccine. 21:2404



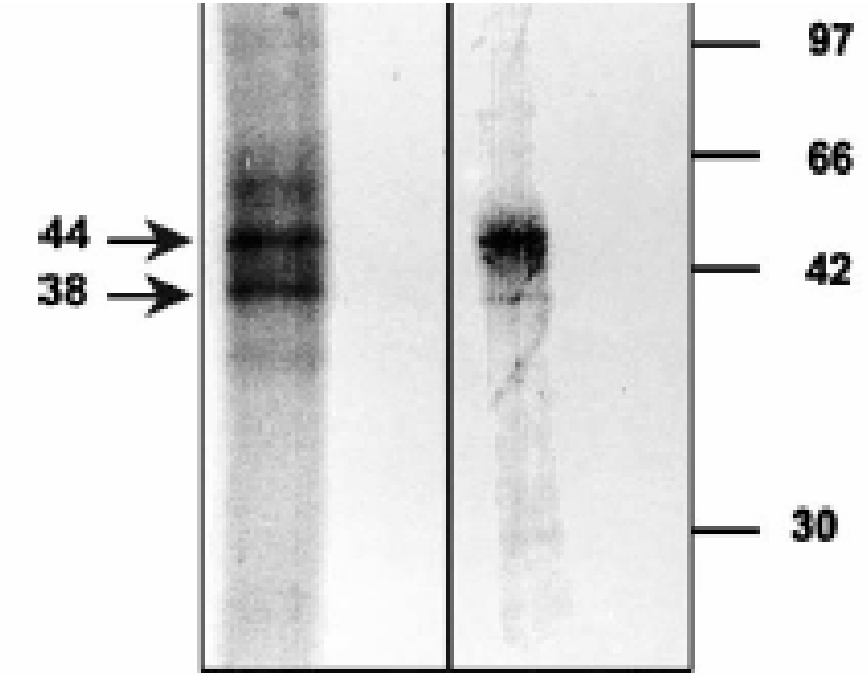
Saturation assays

Lopez R, *et al*, 2003 Vaccine. 21:2404

*Pf*STARP peptide critical residues for Hep G2 cell affinity constants and number of Hep G2 cell binding sites

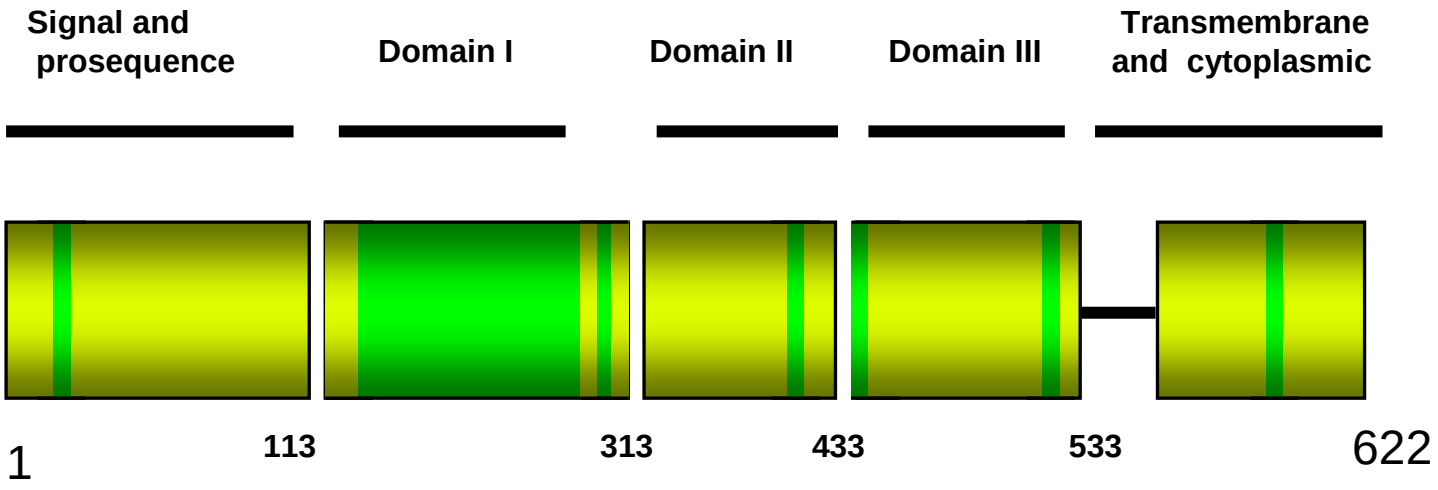
Peptide	Amino acids	Sequence	K_d ± S.D.[a] (nM)	NrSC[b] ± S.D.[a] ($\times 10^3$)
20546	41–60	VIKHNRELSEYQSNFLGGGY	70 ± 5	90 ± 5
20547	61–80	SAALKLVNSKKSGTNVNTKY	219 ± 10	370 ± 10
20548	81–100	NSENTNTNNNPESSSTYTN	110 ± 8	140 ± 8
20569	501–520	TSDDELNKDSSDYSEEKENI	90 ± 6	80 ± 6
20570	521–540	KSMINAYLDKLDLETVRKIH	200 ± 9	360 ± 9

HepG2 cell membrane assay



Apical membrane antigen-1 (AMA-1)

(83 kDa)



Localisation:

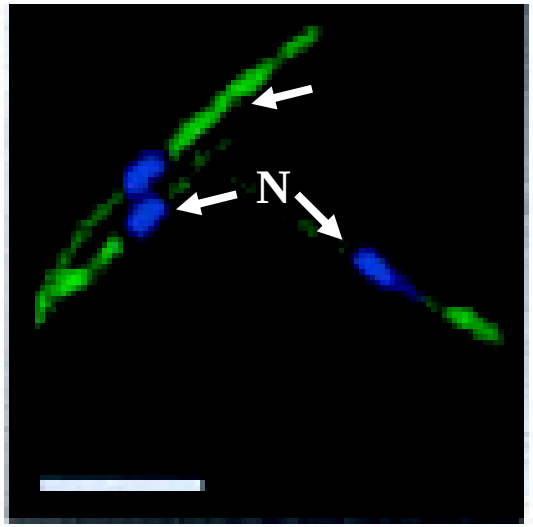
Surface Spz-Mz, micronemes

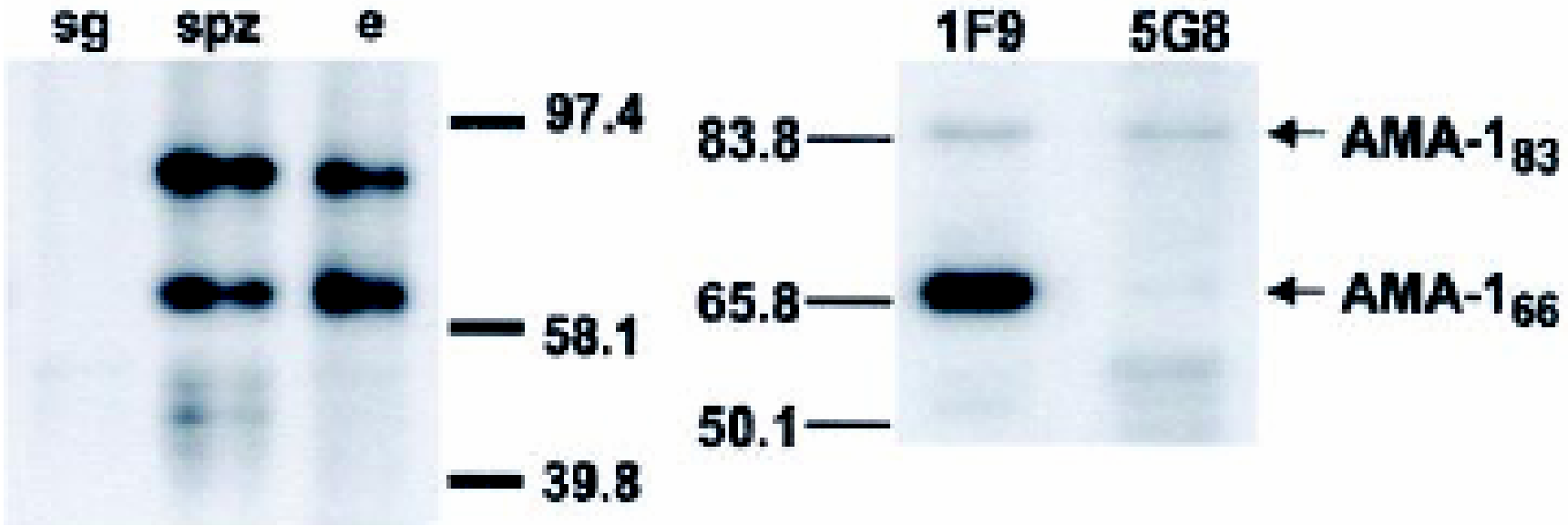
Possible function:

Adhesion, invasion

Silvie O. **et al**. 2004 **J Biol Chem**. 279:9490.

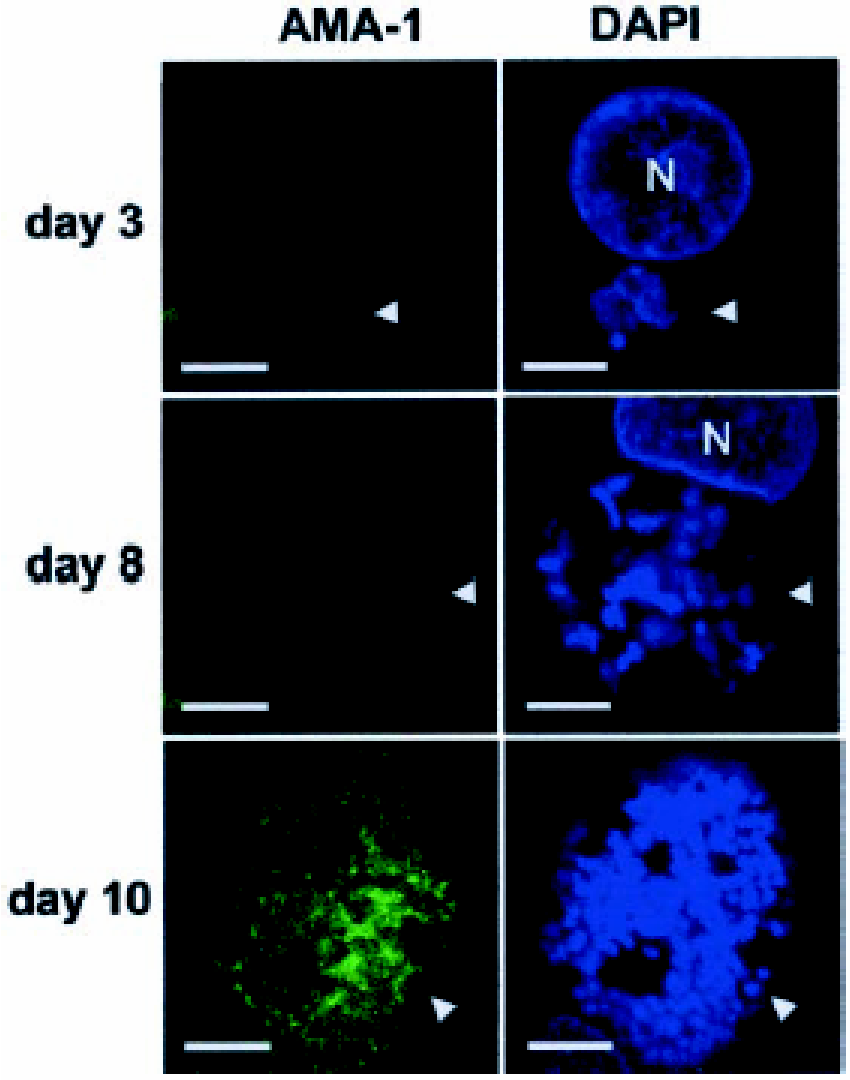
AMA-1 is expressed in *P. falciparum* sporozoites





Silvie O. *et al*. 2004 **J Biol Chem**. 279:9490

AMA-1 is lost after hepatocyte invasion and re-expressed in liver merozoites

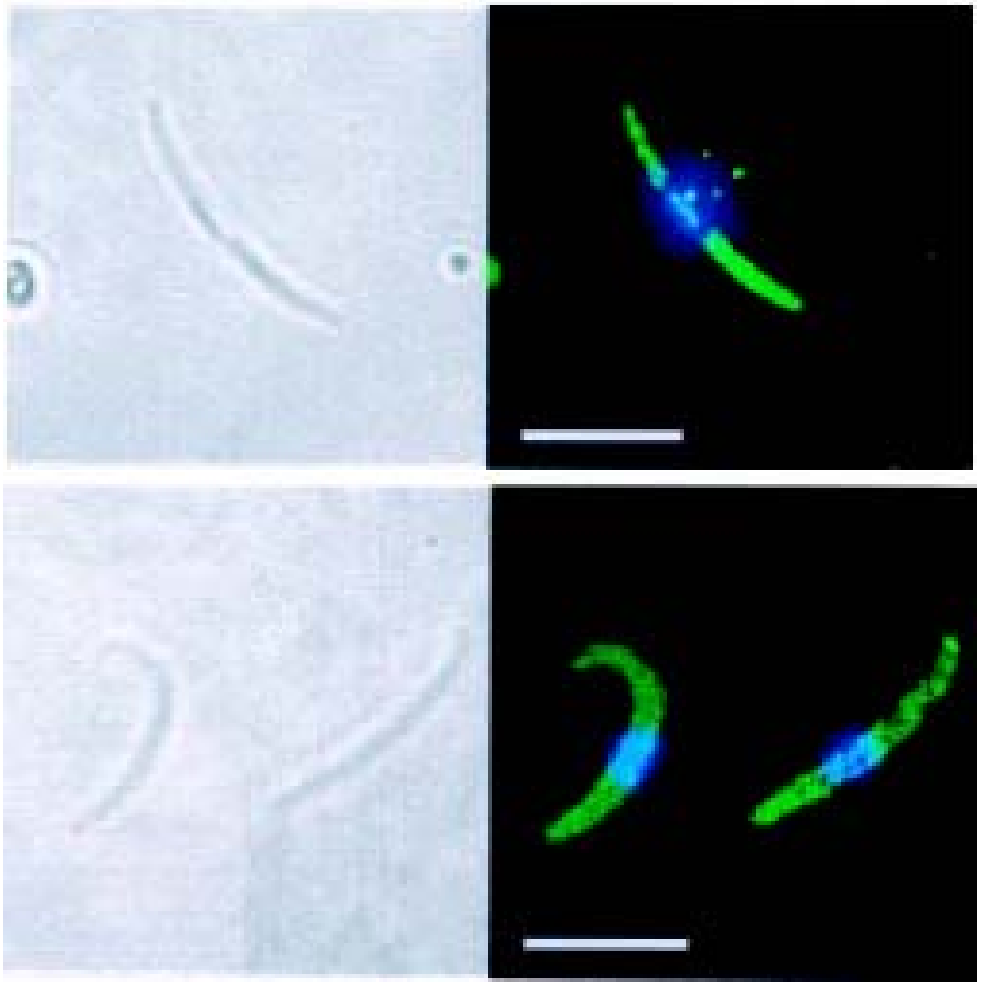


Silvie O. *et al*. 2004 **J Biol Chem**. 279:9490.

Only mature AMA-1 protein translocates to the sporozoite surface

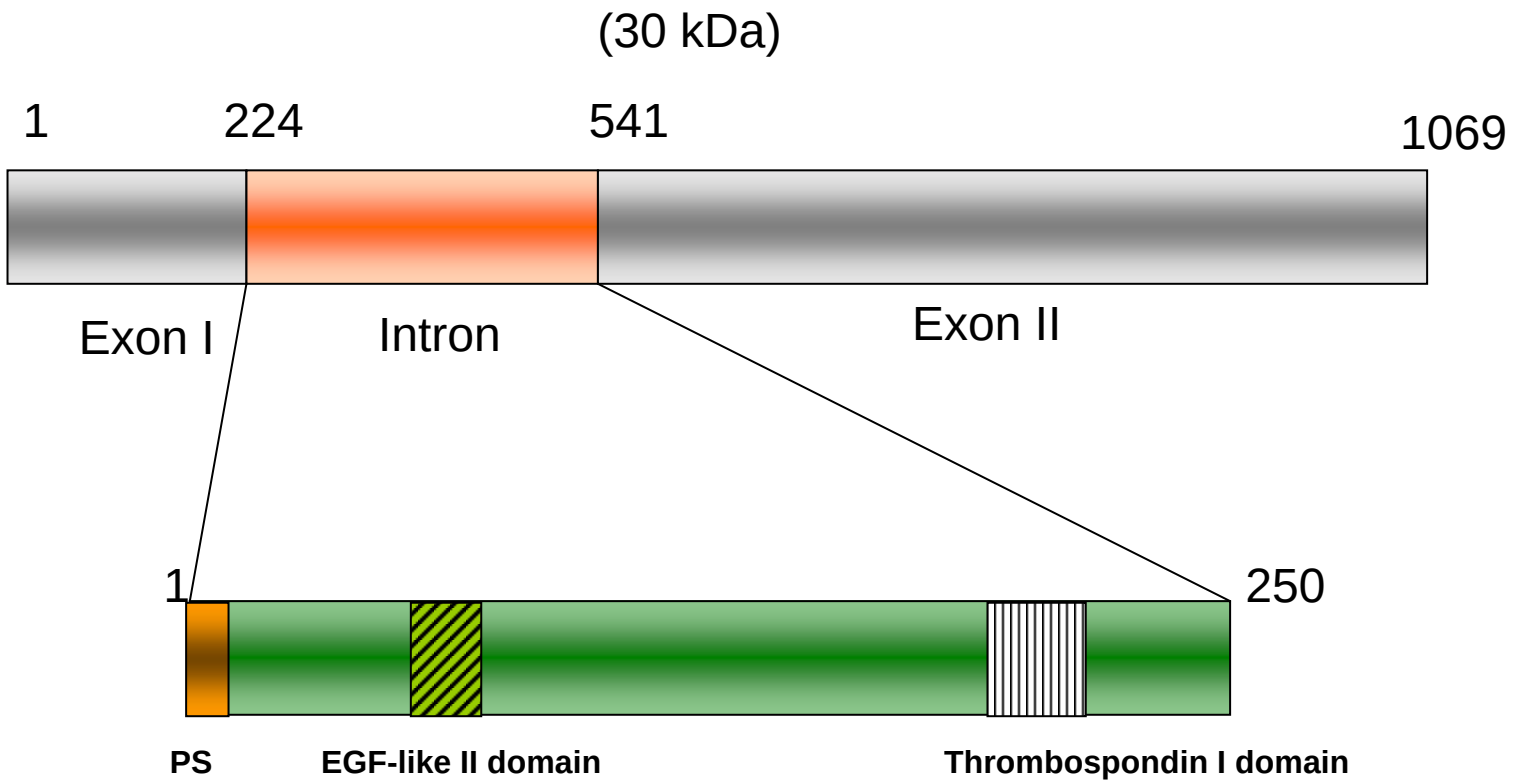
mAb 5G8

mAb 1F9



Silvie O. *et al*. 2004 **J Biol Chem**. 279:9490.

Secreted Protein With Altered Thrombonspondin Type I Repeat Domain (SPATR)



Localisation:

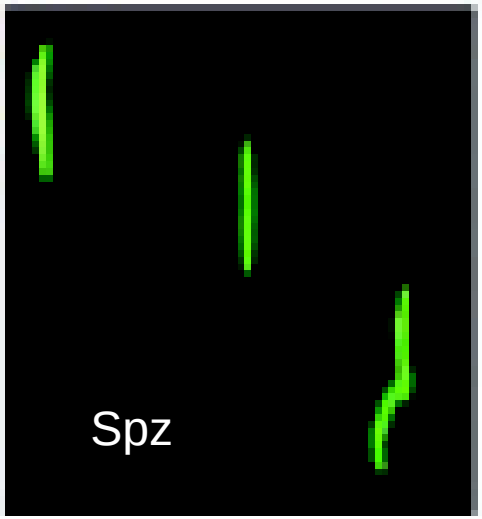
Surface Spz, Liver-Stage, RBC

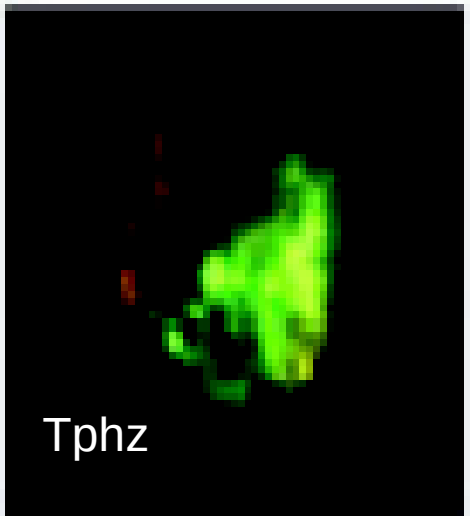
Possible function:

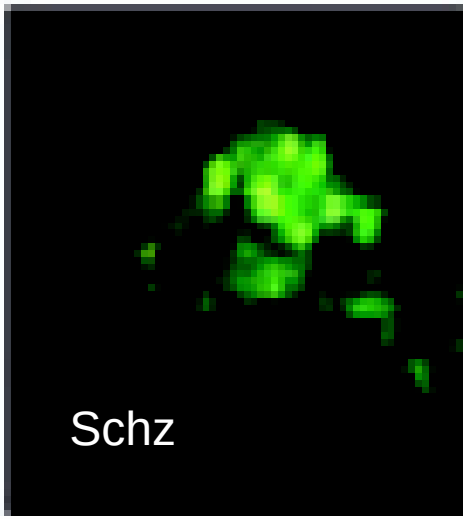
Adhesion, invasion

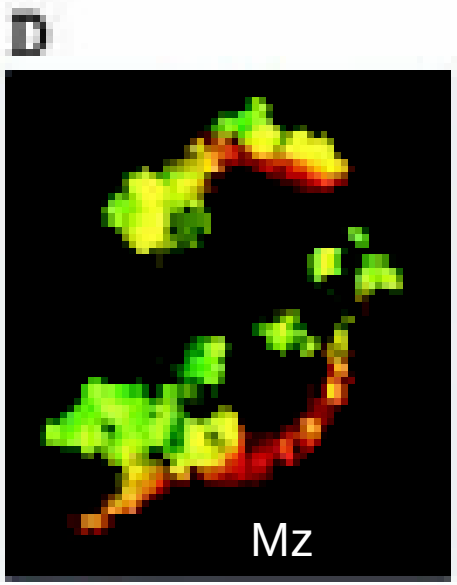
Chattopadhyay R, *et al*, 2003, **J. Biol Chem**. 278: 25977

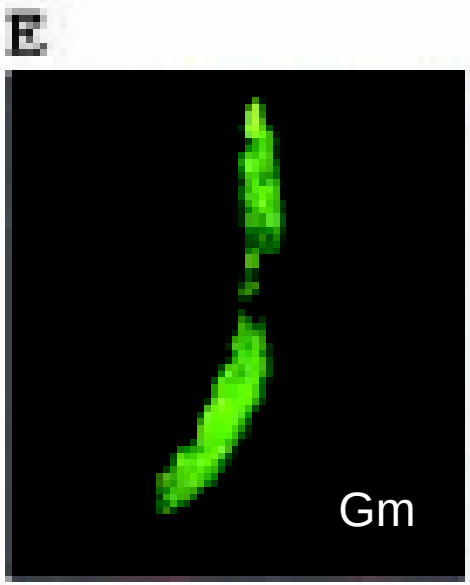
PfSPATR expression in different *P. falciparum* stages





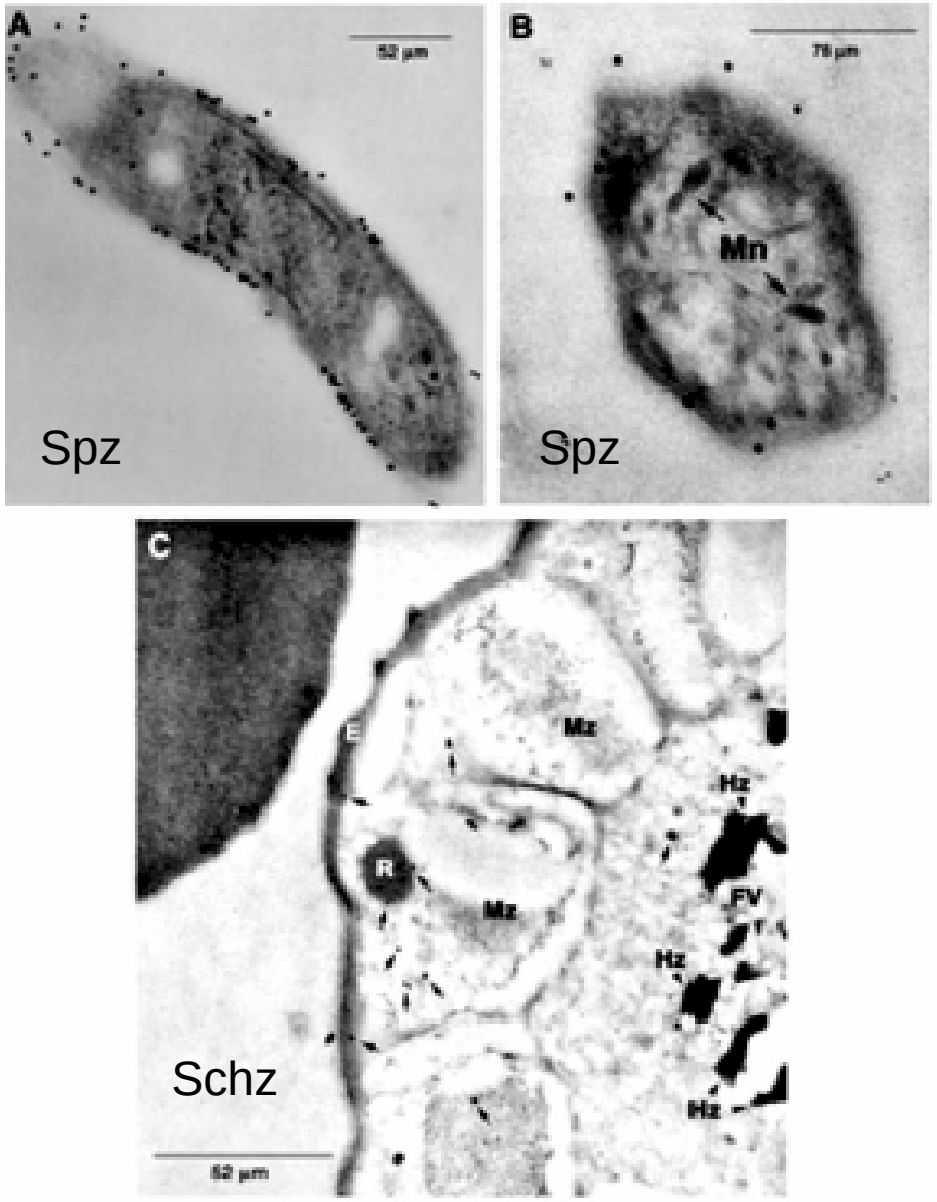






Chattopadhyay R, et al, 2003, J. Biol Chem. 278:25977

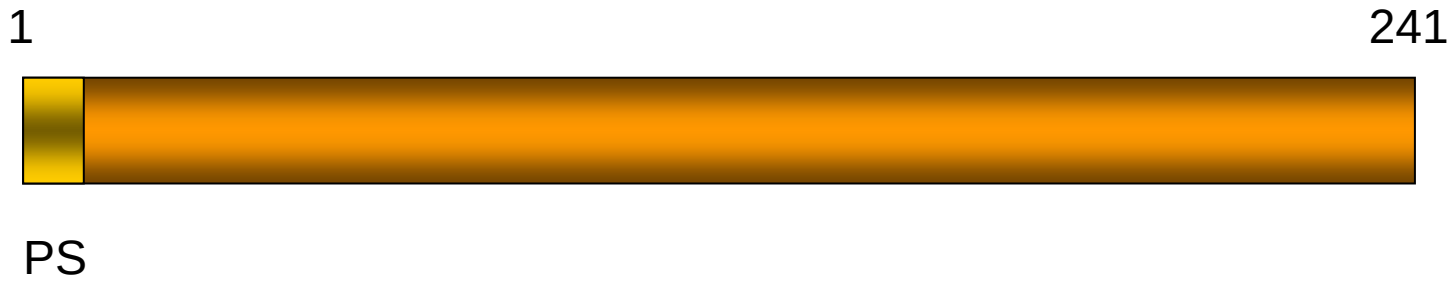
PfSPATR localisation in *P. falciparum* by electron microscopy



Chattopadhyay R, et al, 2003, **J. Biol Chem** 278: 25977

Sporozoite microneme Protein Essential for Cell Traversal (SPECT)

(25 kDa)



Localisation:

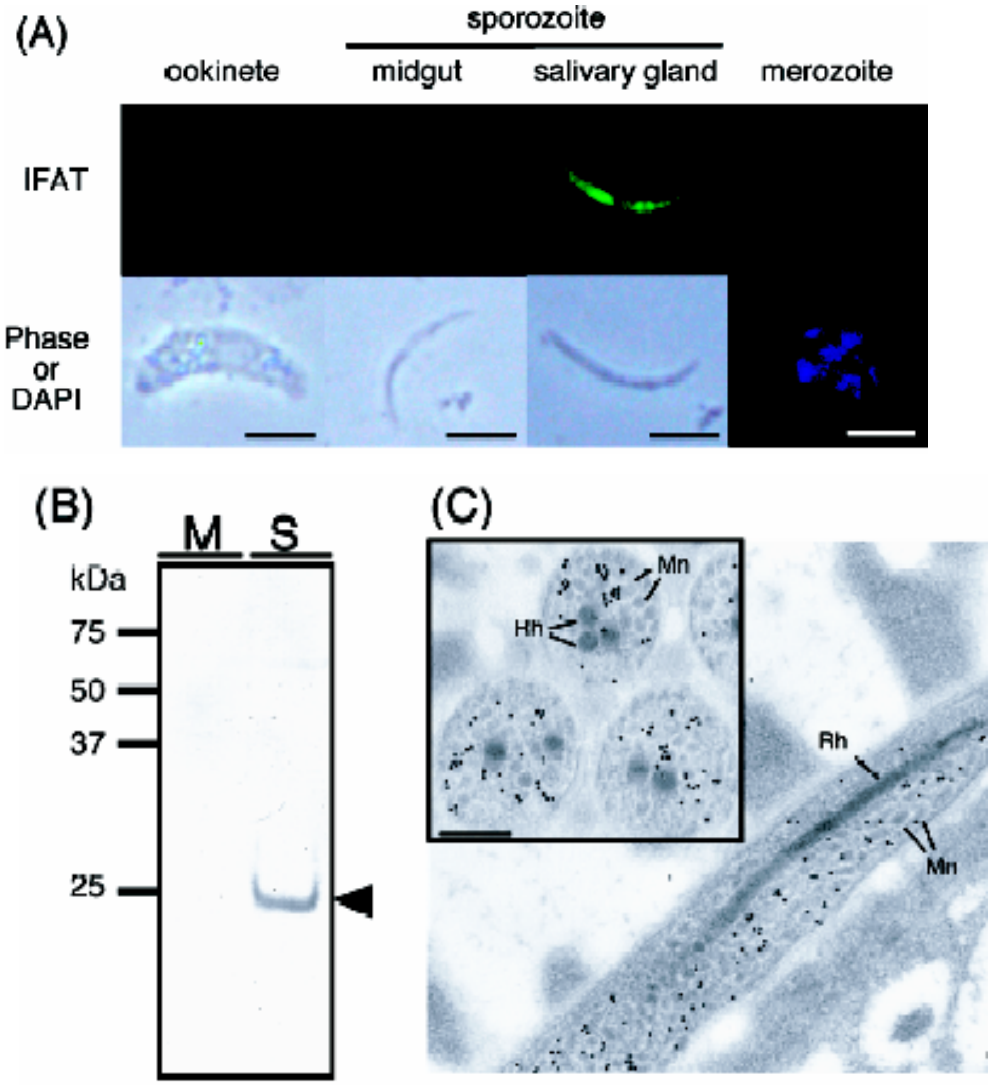
Surface Spz, micronemes

Possible function:

Kupffer cell invasion

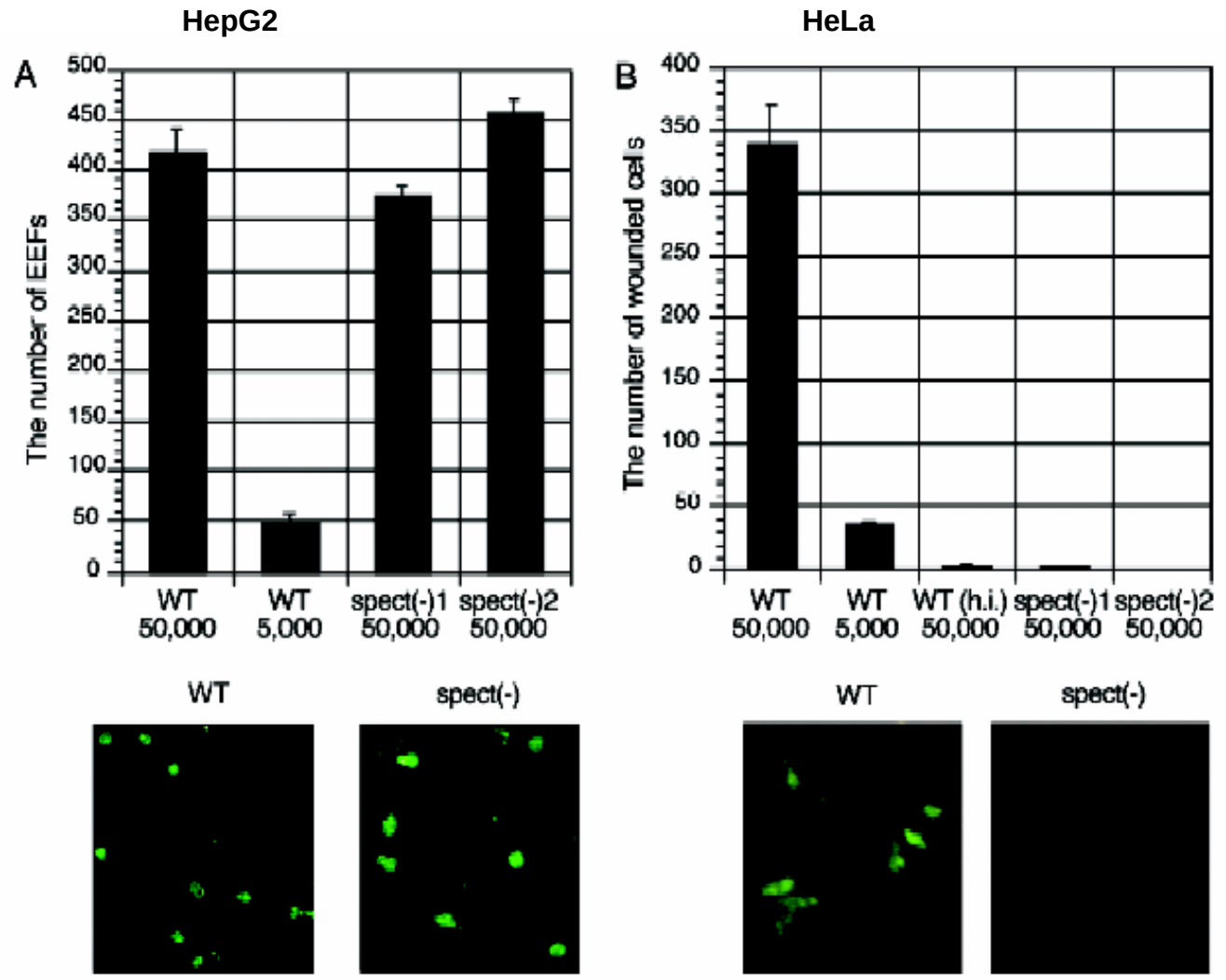
Ishino T. *et al*. 2004. **Plos Biol**. 2:077

SPECT protein specifically produced in infected liver sporozoite stage



Ishino T. *et al*. 2004. **Plos Biol**. 2:077

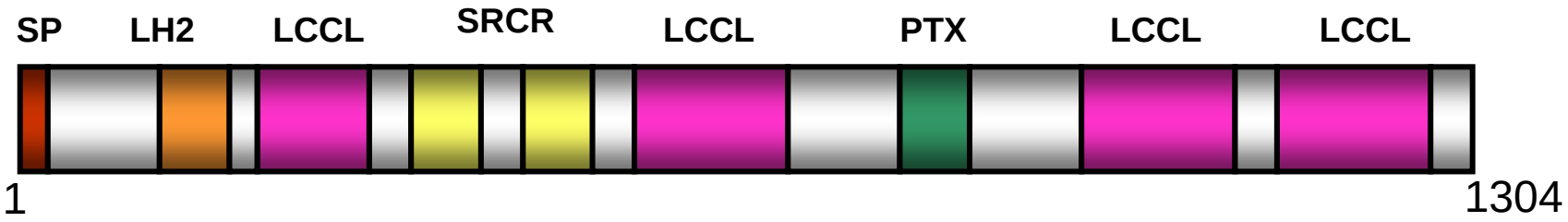
SPECT: sporozoite cell-passage activity



Ishino T. *et al*. 2004. **Plos Biol**. 2:077

Scavenger Receptor Protein (PxSR)

(148 kDa)



SP: Signal peptide. 1x

LH2: Lipoxygenase homology 2 domain. 1x

LCCL: Limulus factor C-like-Coch-5b2-Lf1 clotting domain. 4x

SRCR: Scavenger receptor cysteine-rich. 2x

PTX: PenTraXin domain. 1x

Localisation:

Blood stage, gametocytes, Spz,

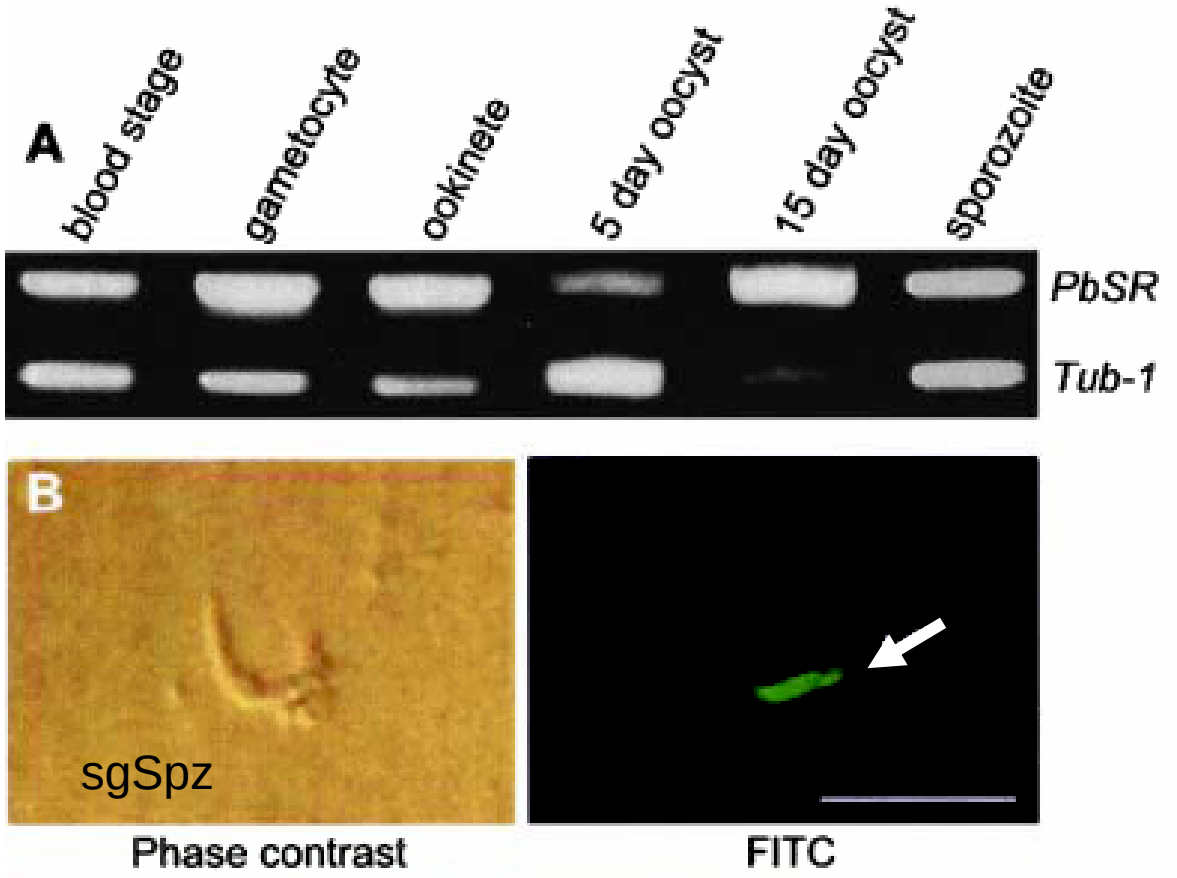
Possible function:

Immune system evasion

Claudianos Ch, et al, 2002, Mol Microbiol

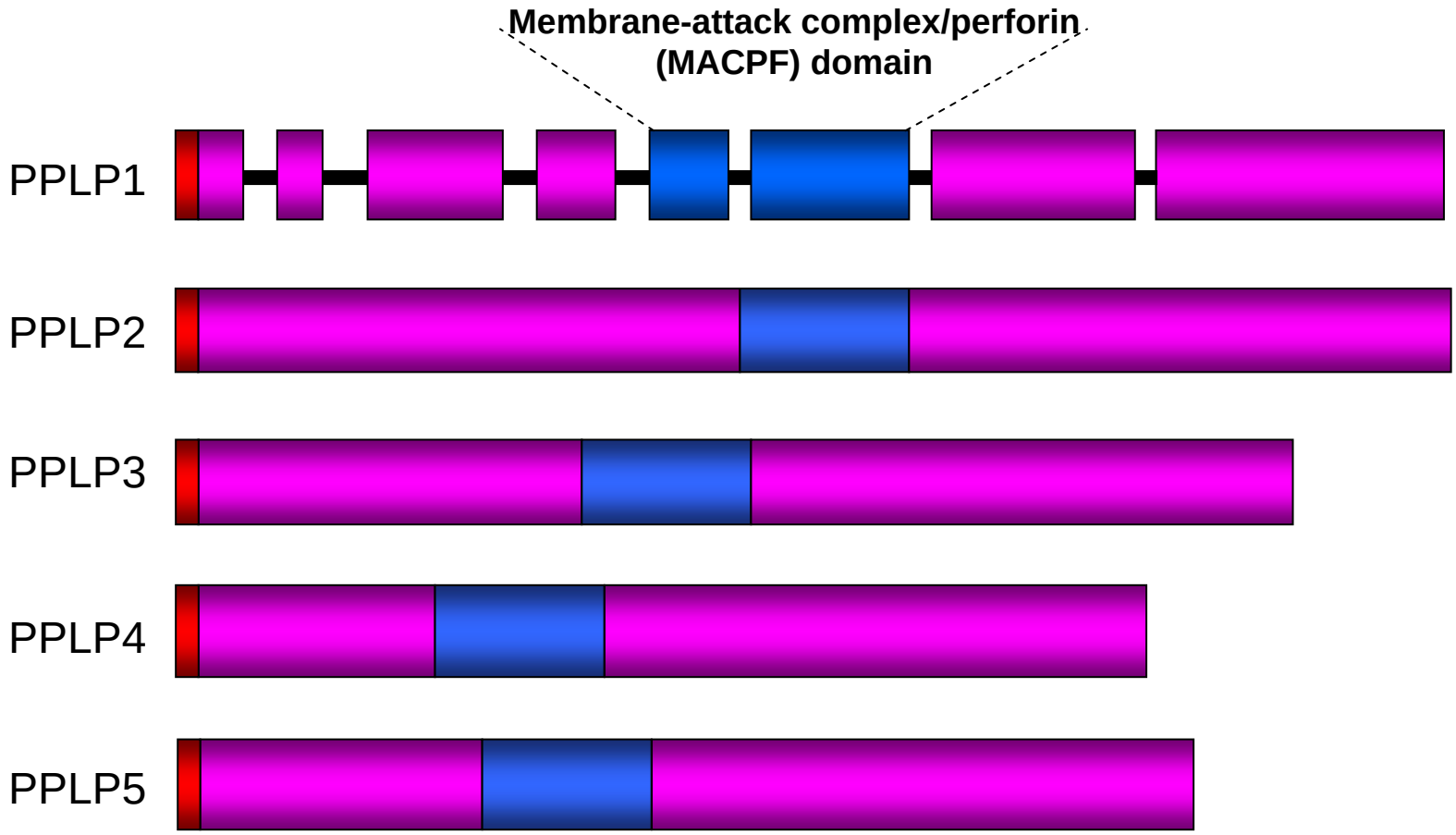
Kappe S, et al, 2003, **Trends Parasitol** 20:102

PxSR expression



Claudianos Ch, *et al*, 2002, **Mol Microbiol** 45: 1473

Plasmodium Perforin-Like Protein Family (PPLP)



Kaiser K *et al*, 2004, **Mol Biochem Parasitol**. 133:15

Overview of the *Plasmodium* perforin-like protein (PPLP) family in *P. falciparum* (Pf) and *P. yoelii* (Py)

	Gene accession number	Protein accession number	Chromosome localization	Predicted mass[a] (kDa)	Amino acid identity (%)
PPLP1					
Pf	PFD 0430C	NP_702743	Chro 4	94	57
Py	PY 00454	EAA 16049[b]	na	91	
PPLP2					
Pf	PFL 0805W	NP_701526	Chro 12	125	49
Py	PY 00181	EAA 21179	na	114	
PPLP3					
Pf	PFI 1145W	NP_704772	Chro 9	93	66
Py	PY05180	EAA 17167[b]	na	92	
PPLP4					
Pf	PF08_0050	NP_704361	Chro 8	76	52
Py	PY03076	EAA 22606[b]	na	79	
PPLP5					
Pf	PF08_0052	NP_704363	Chro 8	79	47
Py	PY03943	EAA 15731	na	80	

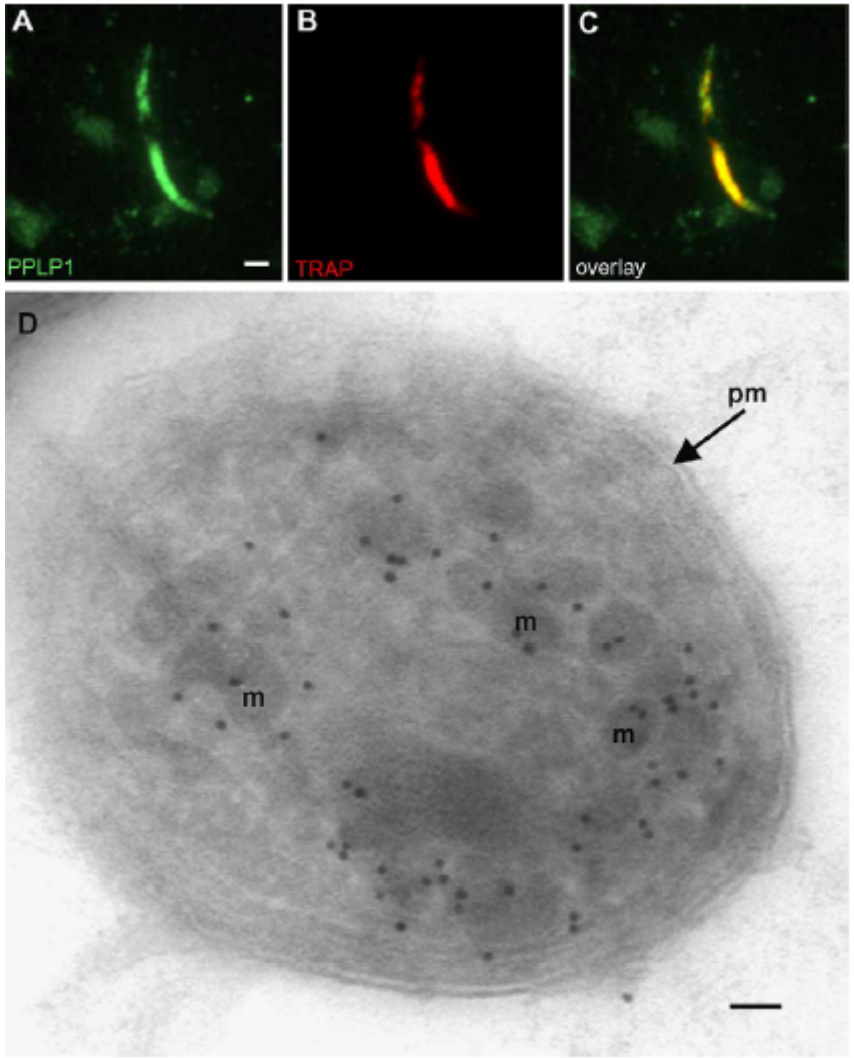
na: not available.

[a] With signal peptide.

[b] Predicted protein was incorrectly annotated.

Kaiser K et al, 2004, **Mol Biochem Parasitol**. 133:15

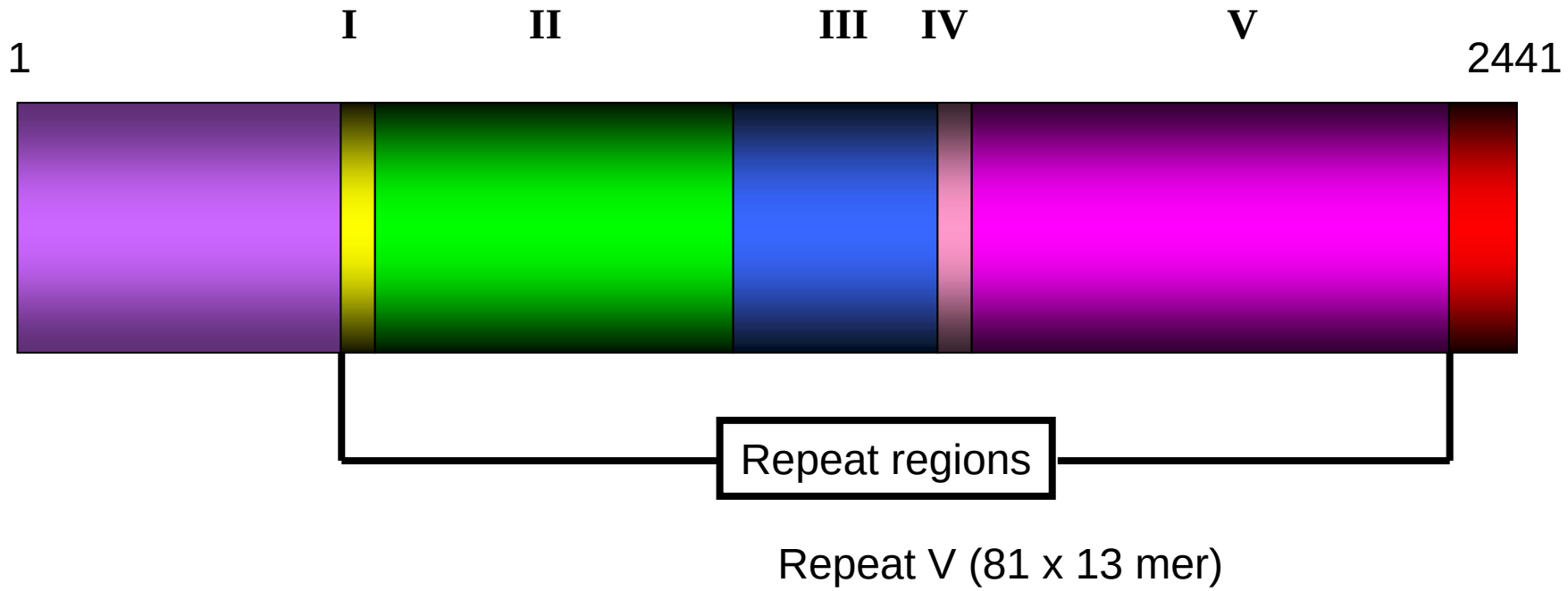
PyPLP1 localises to sporozoite salivary gland micronemes



Kaiser K *et al*, 2004, **Mol Biochem Parasitol.** 133:15

PfEMP3 *Plasmodium falciparum* erythrocyte membrane protein 3

(280 kDa)



Localisation:

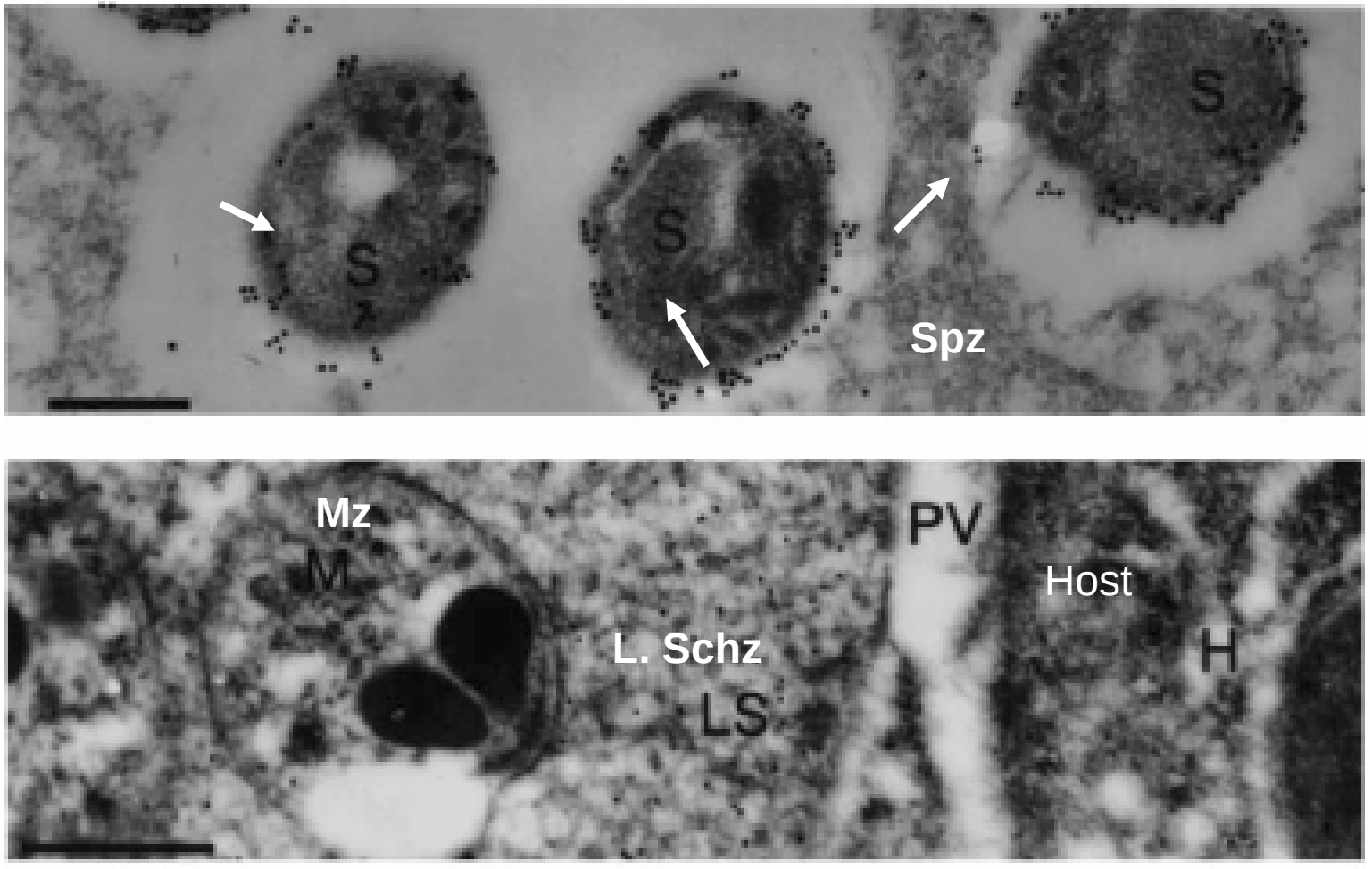
Blood stage, LS, Spz surface

Possible function:

Adhesion, invasion

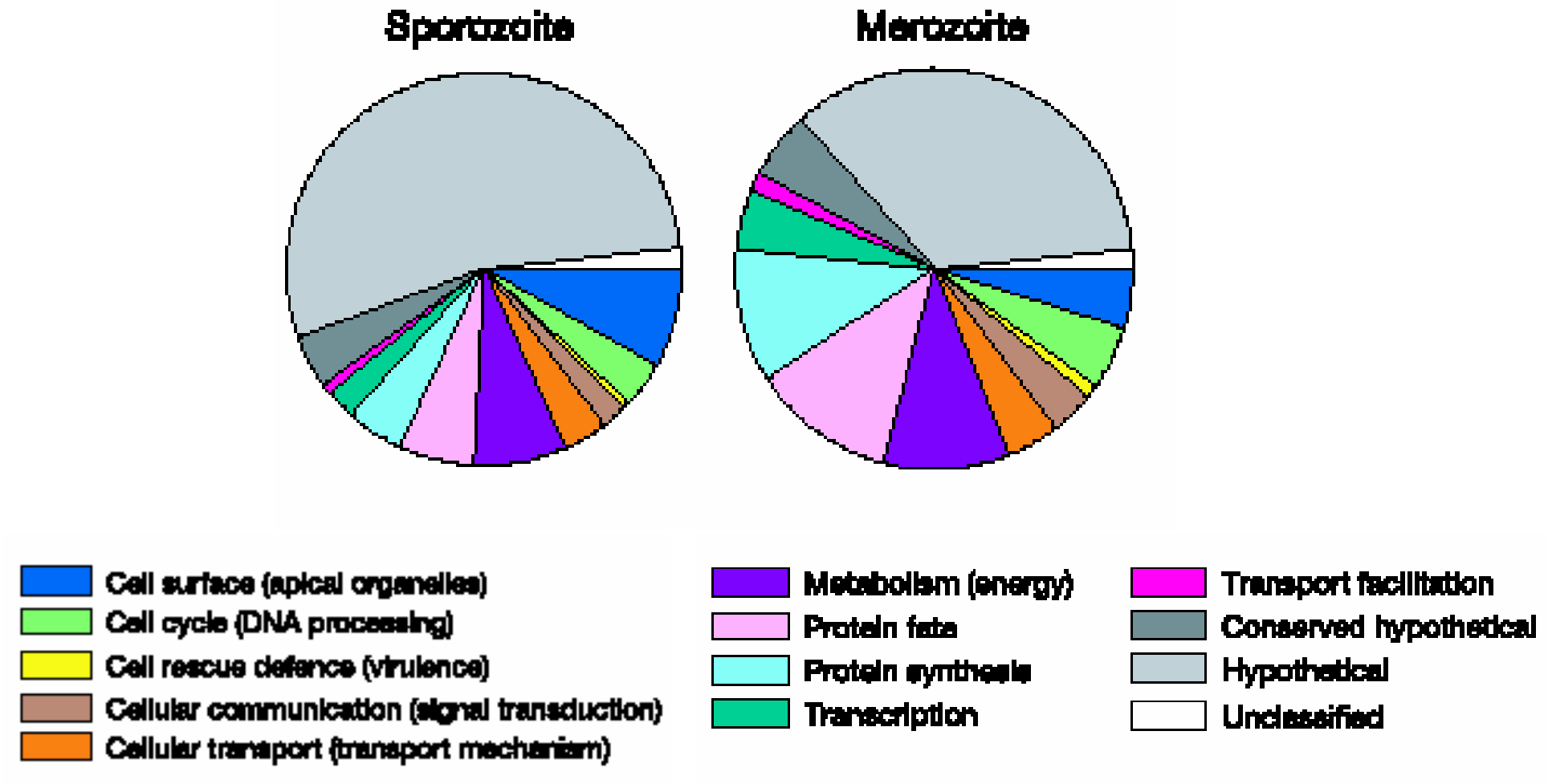
Grüner AC, *et al*. 2001. **Mol. Biochem. Parasitol**. 112:253

PfEMP3 localises to merozoite, sporozoite and liver schizont of *P. falciparum*



Grüner A, *et al*. 2001. **Mol. Biochem. Parasitol**. 112:253

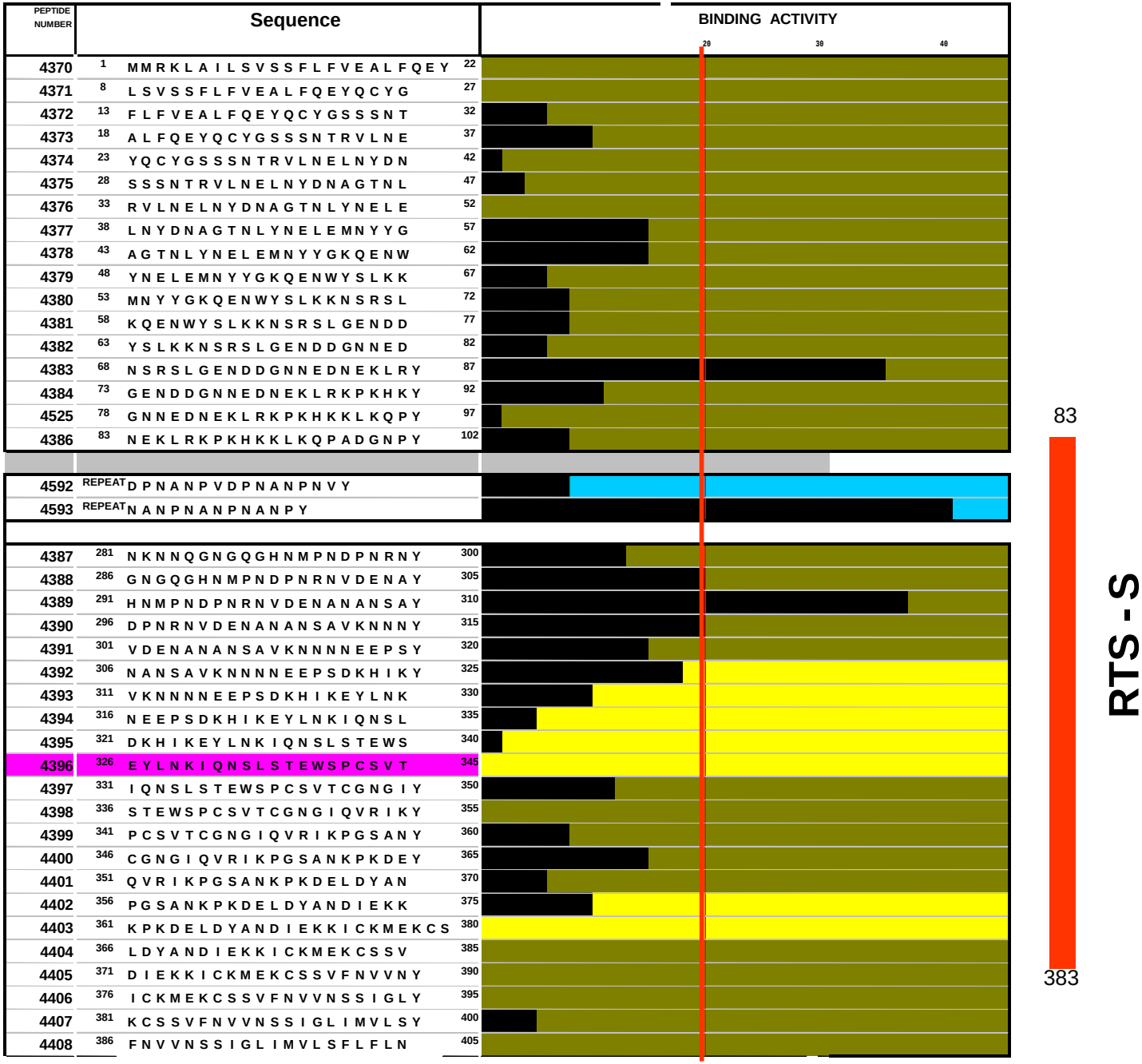
Functional profile of proteins expressed in different *P. falciparum* life-cycle stages



Florens L. *et al.* 2002 **Nature** 419: 520

Plasmodium falciparum circumsporozoite (CS) protein peptides specifically bind to HepG2 cells

Suarez J, et al, 2001, **Vaccine**,19:4487



Plasmodium sporozoite surface and/or apical organelle proteome

Protein	Other stages	Subcellular Localization	Conserved pep
Cs	-	Surface	2
TRAP	-	Surface, micronemes	7
MAEBL	-	Surface, micronemes	
SPECT	-	Micronemes	
EBA175	Mz	Surface, micronemes	
P235	Mz		
AMA1	Mz	Surface, micronemes	
STARP	RBC, LS	Surface	5
SALSA	RBC, LS	Surface	2
PEMP3	RBC, LS	Surface	
LSA3	LS	Surface	11
LSA1	LS		1
P52	-	?	
MCP1	MZ	?	
SPATR	RBC	Surface	
PPLP1	-	Micronemes	
PfEMP1	¡RBC		
STEVOR	¡RBC		
RIFINS	¡RBC		

Adapted of :Baldacci P et al. 2004 **Mol. Microbiol**. 54:298