

# Cell Centered Database

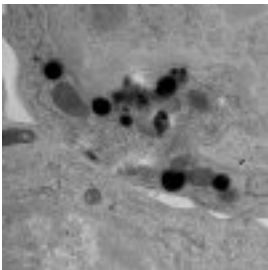
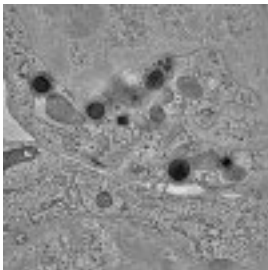
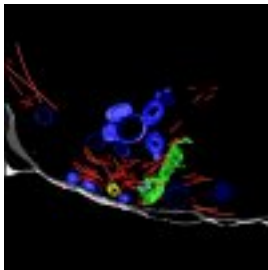
University of California, San Diego

Maryann Martone

Microscopy Product #:3632 CTL\_ImmunSynapse

For the most updated information, please visit

<http://ccdb.ucsd.edu/CCDBWebSite/main?event=displaySum&mpid=3632>

Image2D	Reconstruction	Segmentation
		

## Project Information:

PROJECT_ID	P1694
PROJECT_NAME	Electron Tomography of the CTL Immunological Synapse
PROJECT_DESCRIPTION	Tomogram of the immunological synapse between a human cytotoxic T lymphocyte (CTL) and a target cell
LEADER	Stephen Fuller, Endre Majorovits
FUNDING_AGENCY	Wellcome Trust
PROJECT_START_DATE	2004-02-02 00:00:00.0
PROJECT_END_DATE	
COLLABORATORS	Gillian Griffiths, Jane Stinchcombe, Giovanna Bossi
PUBLICATION1	<a href="#">Jane C. Stinchcombe, Endre Majorovits, Giovanna Bossi, Stephen Fuller, Gillian M. Griffiths. Centrosome polarization delivers secretory granules to the immunological synapse. Nature 443 (2006) 462-465</a>
PUBLICATION2	
PUBLICATION3	

## Experiment Information -

PURPOSE	Defining the structure of the immunological synapse between a human cytotoxic T lymphocyte (CTL) and a target cell and assessing the rearrangement of the microtubule organization center (MTOC) and attached organelles within the CTL during target killing.
TITLE	Structure of the immunological synapse between a human CTL and a target
EXPERIMENTER	Endre Majorovits
EXPERIMENT_NAME	
EXPERIMENT_DATE	2005-11-08 00:00:00.0

<b>Subject Information -</b>	
GROUP_BY	
SUBJECT_NAME	
FIXATION_METHOD_ID	
SCIENTIFIC_NAME	Homo sapiens
SPECIES	Human
STRAIN	healthy
AGE	days
AGECLASS	adult?
ANIMAL_NAME	
LITTER_ID	
SEX	unspecified
VENDOR	
WEIGHT	pounds

<b>Tissue -</b>	
ANATOMIC_LOCATION	blood
MICROTOME	Leica
ORIENTATION	
THICKNESS	.15 um
TISSUE_PROD_STORAGE	EM grid
EXTERNAL_FILE_NAME	
TISSUE_GROUP_TYPE	

<b>Microscopy Product Information -</b>	
MICROSCOPY_PRODUCT_ID	3632
IMAGE_BASENAME	CTL_ImmunSynapse
CREATE_DATE	2006-11-08 00:00:00.0
INSTRUMENT	FEI Tecnai F30
MICROSCOPE_TYPE	HVEM
PLANE_COUNT	
PRODUCT_TYPE	DOUBLE TILT
PURL	
SESSION_NAME	
TELESCIENCE_SRB	P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632
X_RESOLUTION	2.255 nm/pixels
Y_RESOLUTION	2.255 nm/pixels
XSIZE	2048
YSIZE	2048

## Protocol:

CTLs at 13-16 days after stimulation were labelled overnight in the presence of 1-2mg/ml HRP added directly to the growth medium to load the lytic granules then washed 3 times by pelleting and resuspending in RPMI to remove free HRP and serum and the final pellet resuspended at  $5 \times 10^6$  cells/ml. CTL were mixed 1:1 with targets. 1µg/ml PHA or anti-CD3 (UCHT-1) was added for conjugation of human CTL. Conjugates were left in suspension at RT for 5 min then plated in individual wells of 4-well

plastic tissue culture plates (Nunc) and transferred to 37°C for a further 30-60 min. Samples were fixed and processed for DAB-cytochemistry, post-fixed with reduced osmium and EPON embedded. semi-thick were stained with lead citrate and coated with 10nm fiducial gold markers for tomographic reconstruction.

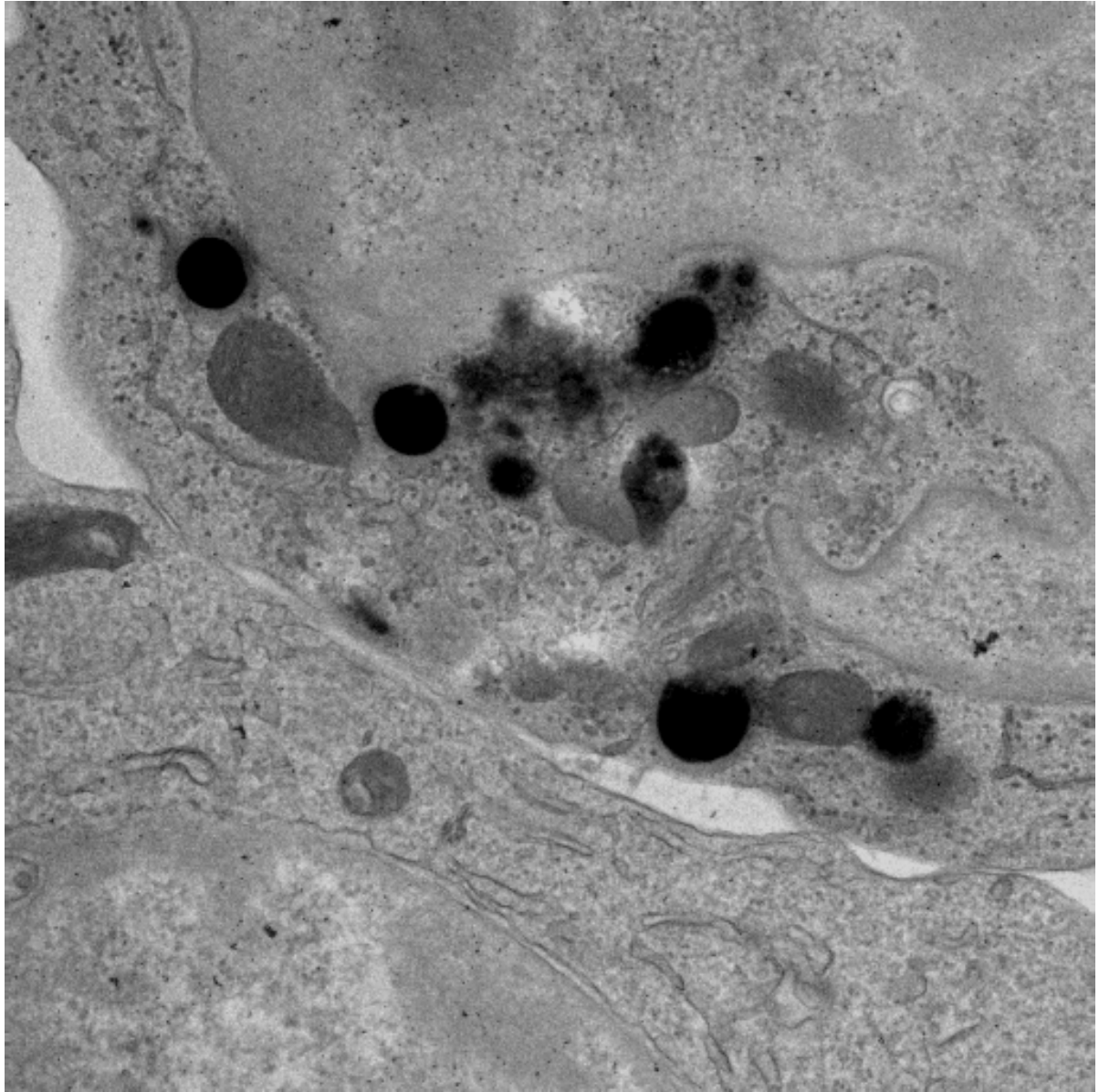
Image Type -	
DOUBLETILTIMAGESEQ_ID	6062
DOUBLET_DESC	Gatan flip-flop holder
RANGE_MAX_X	68 degrees
RANGE_MAX_Y	68 degrees
RANGE_MIN_X	-68 degrees
RANGE_MIN_Y	-68 degrees
DOUBLET_DESC	Gatan flip-flop holder
TILT_INCREMENTX	1degrees
TILT_INCREMENTY	1 degrees

Specimen Description -	
ANATOMICAL_DETAIL	6124
ATLAS_COORD	, ,
CELL_TYPE	Cytotoxic T Lymphocyte
ORGAN	blood
STRUCTURE	CTL immunological synapse
SYSTEM	blood
TISSUE	blood

Electron Microscopy Product -	
EM_PRODUCT_ID	6123
ACCELERATING_VOLTAGE	300 kV
EMBEDDING_MEDIUM	resin
ENERGY_FILTER_SLIT	20 eV
ENERGY_FILTER_TYPE	GIF
MAGNIFICATION	6200
RECORDING_MEDIUM	Slow scan cooled 2K CCD camera

## Raw 2D Image

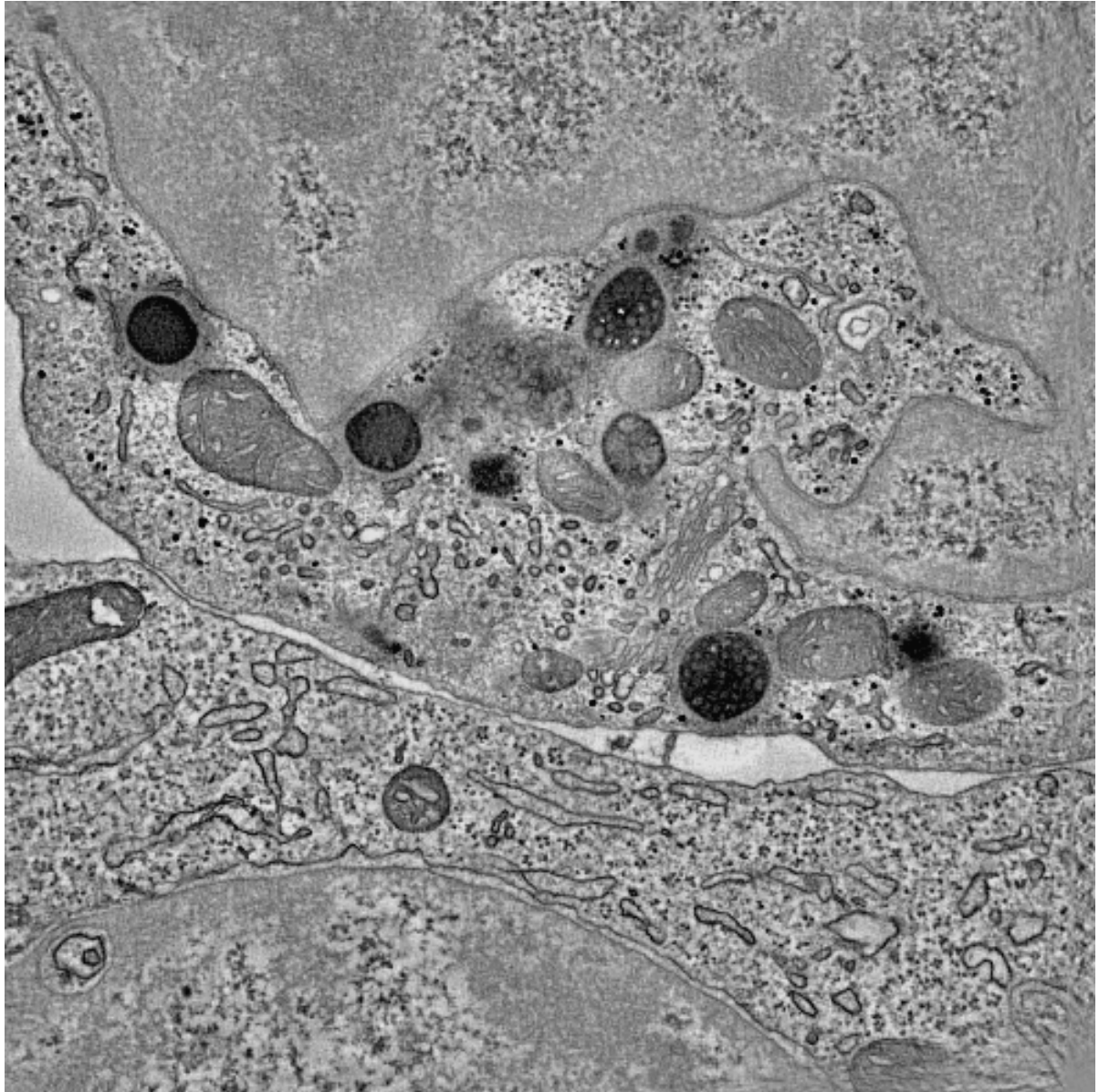
Raw Low Resolution 2D Image -



Raw 2D Image -	
IMAGE2D_ID	6102
DIGITIZED_BY	CCD camera
IMAGE_DATE	2005-08-11 00:00:00.0
IMAGE_DESC	The dual tilt axis series are stored as two MRC files (int, 16 bit): 1. CTL_ImmunSynapse_series_a.mrc, 2. CTL_ImmunSynapse_series_b.mrc The gzipped tar file was created on a LINUX machine: tar -czf CTL_ImmunSynapse_img.tar.gz *mrc
IMAGE_FILE_FORMAT	imod
IMAGE_FILE_NAME	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_img.jpg
MAGNIFICATION	6200 X
RAW_DATA_FILE	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_img.tar.gz
THUMBNAIL_DESC	Projection of the untilted specimen: immunological synapse between a human cytotoxix T lymphocyte (top) and a target cell (bottom).
THUMBNAIL_FILE	P1694/CTL_ImmunSynapse_img_small.jpg
X_RESOLUTION	.00225 um/pixel
Y_RESOLUTION	.00225 um/pixel
X_SIZE	2048 pixels
Y_SIZE	2048 pixels

# Reconstruction

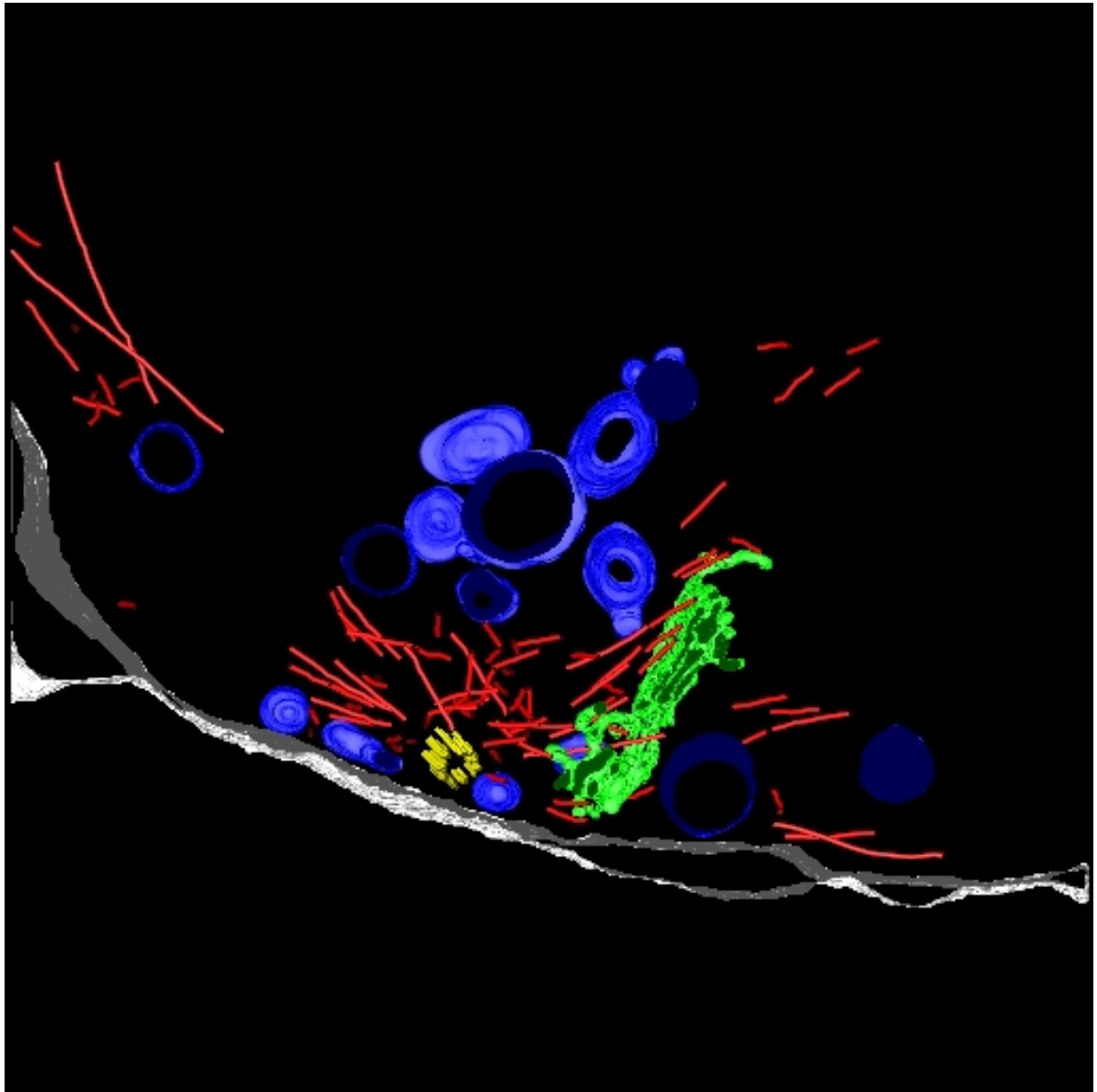
Reconstruction Image -



<b>Reconstruction -</b>	
RECONSTRUCTION3D_ID	6084
ALIGNMENT_METHOD	Imod
ALIGNMENT_PROGRAM	IMOD
CROPPING_COORDINATE1	,
CROPPING_COORDINATE2	,
RECON_ALGORITHM	R-weighted back projection
RECON_DATE	2005-12-13 00:00:00.0
RECON_DESC	The tomographic reconstruction is stored as an MRC file (int, 8 bit): CTL_ImmunSynapse_rec.mrc.gz The tomogram has been Gauss-filtered with AMIRA (filter parameters: 3D, Sigma x=y=z=1, Kernel x=y=z=3) as an MRC file (int, 8 bit): CTL_ImmunSynapse_filter_rec.mrc Segmentation was done using the filtered tomogram. The tar file was created on a LINUX machine: tar -cf CTL_ImmunSynapse_vol.tar *mrc
RECON_PROGRAM	IMOD
RECON_TYPE	double tilt electron tomography
VOLUME_DIMENSION	2048, 2048, 76
VOLUME_NAME	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_vol.tar
VOXEL_SCALE	.00225, .00225, .00225
RECONSTRUCTION_IMAGES_ID	6084
RECON_IMAGE_DESC	Tomogram of the immunological synapse between a cytotoxic T lymphocyte (CTL, top) and a target cell (bottom). The microtubule organization centre (MTOC) is polarized to the cell-cell contact site. The electron-dense lytic granules are transported along the microtubules to the synaptic cleft. Here they probably fuse with the membrane and excrete the cytotoxic proteins that trigger the death of the target cell.
RECON_FILE_NAME	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_vol.jpg
VOLUME_THUMBNAIL	P1694/CTL_ImmunSynapse_vol_small.jpg
ANIMATION_FILE	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_vol.avi
ANIMATION_FILE_FORMAT	AVI
ANIMATION_DESC	Movie showing the tomogram of the immunological synapse between a cytotoxic T lymphocyte (CTL, top) and a target cell (bottom). The microtubule organization centre (MTOC) is polarized to the cell-cell contact site. The electron-dense lytic granules are transported along the microtubules to the synaptic cleft. Here they probably fuse with the membrane and excrete the cytotoxic proteins that trigger the death of the target cell.

## Segmentation

Segmentation Image -





Segmentation -	
SEGMENTED_OBJECT_ID	6110
DISPLAY_IMAGE_DESC	Model of the immunological synapse between a cytotoxic T lymphocyte (top) and a target cell (bottom). The centriole (yellow) forms part of the microtubule organization centre (MTOC) and is polarized to the cell-cell contact site. The microtubules (red) radiate out from the polarized centrosomal area, running both away from the plasma membrane into the cell and along the cell membrane (grey) to the periphery of the synapse. Both lytic granules (blue) and the Golgi apparatus (green) are linked to and transported along the microtubules to the synaptic cleft.
DOWNLOADABLE_FILE_DESC	Segmentation has been done with IMOD and AMIRA. The following objects have been segmented: 1. centriole (in the CTL), 2. microtubules (in the CTL), 3. Golgi apparatus (in the CTL), 4. lytic granules (in the CTL), 5. synaptic cleft (between CTL and target cell). The final model is an IMOD model file: CTL_ImmunSynapse_IMOD.mod.gz (it is gzipped on a LINUX machine: gzip CTL_ImmunSynapse_IMOD.mod). Masks representing the various objects were generated in MRC format (int, 8 bit): 1. CTL_ImmunSynapse_centriole.mrc.gz, 2. CTL_ImmunSynapse_microtubules.mrc.gz, 3. CTL_ImmunSynapse_Golgi.mrc.gz, 4. CTL_ImmunSynapse_granules.mrc.gz, 5. CTL_ImmunSynapse_synapse.mrc.gz (files are gzipped on a LINUX machine: gzip CTL_ImmunSynapse_*.mrc). The tar file was created on a LINUX machine: tar -cf CTL_ImmunSynapse_seg.tar CTL_ImmunSynapse_*.gz
IS_MANUAL	Y
LABELING_INTENSITY	1 um $\mu\mu\mu$
LABELING_RANK	none
NUMBER_OF_OBJECT	1
OBJECT_NAME	centriole
SEGMENTED_OBJ_2D_IMAGE	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_seg.jpg
SEGMENTED_OBJECT_ID	6110
SEGMENT_PERSON_NAME	Endre Majorovits
SEG_ALGORITHM	Manual via IMOD
SEG_DESC	Segmentation of centriole, microtubules, Golgi apparatus and lytic granules within the CTL and of the synaptic cleft.
SEG_FILE_NAME	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_seg.tar
THRESHHOLD	.5 um $\mu\mu\mu$
THUMBNAIL	P1694/CTL_ImmunSynapse_seg_small.jpg
SEGMENTED_OBJECT_ID	6114
DISPLAY_IMAGE_DESC	Model of the immunological synapse between a cytotoxic T lymphocyte (top) and a target cell (bottom). The centriole (yellow)

Segmentation -	
	forms part of the microtubule organization centre (MTOC) and is polarized to the cell-cell contact site. The microtubules (red) radiate out from the polarized centrosomal area, running both away from the plasma membrane into the cell and along the cell membrane (grey) to the periphery of the synapse. Both lytic granules (blue) and the Golgi apparatus (green) are linked to and transported along the microtubules to the synaptic cleft.
DOWNLOADABLE_FILE_DESC	Segmentation has been done with IMOD and AMIRA. The following objects have been segmented: 1. centriole (in the CTL), 2. microtubules (in the CTL), 3. Golgi apparatus (in the CTL), 4. lytic granules (in the CTL), 5. synaptic cleft (between CTL and target cell). The final model is an IMOD model file: CTL_ImmunSynapse_IMOD.mod.gz (it is gzipped on a LINUX mashine: gzip CTL_ImmunSynapse_IMOD.mod). Masks representing the various objects were generated in MRC format (int, 8 bit): 1. CTL_ImmunSynapse_centriole.mrc.gz, 2. CTL_ImmunSynapse_microtubules.mrc.gz, 3. CTL_ImmunSynapse_Golgi.mrc.gz, 4. CTL_ImmunSynapse_granules.mrc.gz, 5. CTL_ImmunSynapse_synapse.mrc.gz (files are gzipped on a LINUX mashine: gzip CTL_ImmunSynapse_*.mrc). The tar file was created on a LINUX machine: tar -cf CTL_ImmunSynapse_seg.tar CTL_ImmunSynapse_*.gz
IS_MANUAL	Y
LABELING_INTENSITY	1 um $\mu$ m $\mu$ m
LABELING_RANK	none
NUMBER_OF_OBJECT	1
OBJECT_NAME	synaptic cleft
SEGMENTED_OBJ_2D_IMAGE	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_seg.jpg
SEGMENTED_OBJECT_ID	6114
SEGMENT_PERSON_NAME	Endre Majorovits
SEG_ALGORITHM	Manual via IMOD
SEG_DESC	Segmentation of centriole, microtubules, Golgi apparatus and lytic granules within the CTL and of the synaptic cleft.
SEG_FILE_NAME	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_seg.tar
THRESHHOLD	.5 um $\mu$ m $\mu$ m
THUMBNAIL	P1694/CTL_ImmunSynapse_seg_small.jpg
SEGMENTED_OBJECT_ID	6111
DISPLAY_IMAGE_DESC	Model of the immunological synapse between a cytotoxic T lymphocyte (top) and a target cell (bottom). The centriole (yellow) forms part of the microtubule organization centre (MTOC) and is polarized to the cell-cell contact site. The microtubules (red) radiate out from the polarized centrosomal area, running both away from the plasma membrane into the cell and along the cell membrane (grey)

Segmentation -	
	to the periphery of the synapse. Both lytic granules (blue) and the Golgi apparatus (green) are linked to and transported along the microtubules to the synaptic cleft.
DOWNLOADABLE_FILE_DESC	Segmentation has been done with IMOD and AMIRA. The following objects have been segmented: 1. centriole (in the CTL), 2. microtubules (in the CTL), 3. Golgi apparatus (in the CTL), 4. lytic granules (in the CTL), 5. synaptic cleft (between CTL and target cell). The final model is an IMOD model file: CTL_ImmunSynapse_IMOD.mod.gz (it is gzipped on a LINUX mashine: gzip CTL_ImmunSynapse_IMOD.mod). Masks representing the various objects were generated in MRC format (int, 8 bit): 1. CTL_ImmunSynapse_centriole.mrc.gz, 2. CTL_ImmunSynapse_microtubules.mrc.gz, 3. CTL_ImmunSynapse_Golgi.mrc.gz, 4. CTL_ImmunSynapse_granules.mrc.gz, 5. CTL_ImmunSynapse_synapse.mrc.gz (files are gzipped on a LINUX mashine: gzip CTL_ImmunSynapse_*.mrc). The tar file was created on a LINUX machine: tar -cf CTL_ImmunSynapse_seg.tar CTL_ImmunSynapse_*.gz
IS_MANUAL	Y
LABELING_INTENSITY	1 um $\mu$
LABELING_RANK	none
NUMBER_OF_OBJECT	1
OBJECT_NAME	microtubules
SEGMENTED_OBJ_2D_IMAGE	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_seg.jpg
SEGMENTED_OBJECT_ID	6111
SEGMENT_PERSON_NAME	Endre Majorovits
SEG_ALGORITHM	Manual via IMOD
SEG_DESC	Segmentation of centriole, microtubules, Golgi apparatus and lytic granules within the CTL and of the synaptic cleft.
SEG_FILE_NAME	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_seg.tar
THRESHHOLD	.5 um $\mu$
THUMBNAIL	P1694/CTL_ImmunSynapse_seg_small.jpg
SEGMENTED_OBJECT_ID	6112
DISPLAY_IMAGE_DESC	Model of the immunological synapse between a cytotoxic T lymphocyte (top) and a target cell (bottom). The centriole (yellow) forms part of the microtubule organization centre (MTOC) and is polarized to the cell-cell contact site. The microtubules (red) radiate out from the polarized centrosomal area, running both away from the plasma membrane into the cell and along the cell membrane (grey) to the periphery of the synapse. Both lytic granules (blue) and the Golgi apparatus (green) are linked to and transported along the microtubules to the synaptic cleft.
DOWNLOADABLE_FILE_DESC	Segmentation has been done with IMOD and AMIRA. The following

## Segmentation -

	objects have been segmented: 1. centriole (in the CTL), 2. microtubules (in the CTL), 3. Golgi apparatus (in the CTL), 4. lytic granules (in the CTL), 5. synaptic cleft (between CTL and target cell). The final model is an IMOD model file: CTL_ImmunSynapse_IMOD.mod.gz (it is gzipped on a LINUX machine: gzip CTL_ImmunSynapse_IMOD.mod). Masks representing the various objects were generated in MRC format (int, 8 bit): 1. CTL_ImmunSynapse_centriole.mrc.gz, 2. CTL_ImmunSynapse_microtubules.mrc.gz, 3. CTL_ImmunSynapse_Golgi.mrc.gz, 4. CTL_ImmunSynapse_granules.mrc.gz, 5. CTL_ImmunSynapse_synapse.mrc.gz (files are gzipped on a LINUX machine: gzip CTL_ImmunSynapse_*.mrc). The tar file was created on a LINUX machine: tar -cf CTL_ImmunSynapse_seg.tar CTL_ImmunSynapse_*.gz
IS_MANUAL	Y
LABELING_INTENSITY	1 um $\bar{\mu}$ $\bar{\mu}$ $\bar{\mu}$
LABELING_RANK	none
NUMBER_OF_OBJECT	1
OBJECT_NAME	Golgi apparatus
SEGMENTED_OBJ_2D_IMAGE	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_seg.jpg
SEGMENTED_OBJECT_ID	6112
SEGMENT_PERSON_NAME	Endre Majorovits
SEG_ALGORITHM	Manual via IMOD
SEG_DESC	Segmentation of centriole, microtubules, Golgi apparatus and lytic granules within the CTL and of the synaptic cleft.
SEG_FILE_NAME	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_seg.tar
THRESHHOLD	.5 um $\bar{\mu}$ $\bar{\mu}$ $\bar{\mu}$
THUMBNAIL	P1694/CTL_ImmunSynapse_seg_small.jpg
SEGMENTED_OBJECT_ID	6113
DISPLAY_IMAGE_DESC	Model of the immunological synapse between a cytotoxic T lymphocyte (top) and a target cell (bottom). The centriole (yellow) forms part of the microtubule organization centre (MTOC) and is polarized to the cell-cell contact site. The microtubules (red) radiate out from the polarized centrosomal area, running both away from the plasma membrane into the cell and along the cell membrane (grey) to the periphery of the synapse. Both lytic granules (blue) and the Golgi apparatus (green) are linked to and transported along the microtubules to the synaptic cleft.
DOWNLOADABLE_FILE_DESC	Segmentation has been done with IMOD and AMIRA. The following objects have been segmented: 1. centriole (in the CTL), 2. microtubules (in the CTL), 3. Golgi apparatus (in the CTL), 4. lytic granules (in the CTL), 5. synaptic cleft (between CTL and target cell). The final model is an IMOD model file:

## Segmentation -

	CTL_ImmunSynapse_IMOD.mod.gz (it is gzipped on a LIMUX mashine: gzip CTL_ImmunSynapse_IMOD.mod). Masks representing the various objects were generated in MRC format (int, 8 bit): 1. CTL_ImmunSynapse_centriole.mrc.gz, 2. CTL_ImmunSynapse_microtubules.mrc.gz, 3. CTL_ImmunSynapse_Golgi.mrc.gz, 4. CTL_ImmunSynapse_granules.mrc.gz, 5. CTL_ImmunSynapse_synapse.mrc.gz (files are gzipped on a LIMUX mashine: gzip CTL_ImmunSynapse_*.mrc). The tar file was created on a LINUX machine: tar -cf CTL_ImmunSynapse_seg.tar CTL_ImmunSynapse_*.gz
IS_MANUAL	Y
LABELING_INTENSITY	1 um $\mu\mu\mu$
LABELING_RANK	none
NUMBER_OF_OBJECT	1
OBJECT_NAME	lytic granlues
SEGMENTED_OBJ_2D_IMAGE	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_seg.jpg
SEGMENTED_OBJECT_ID	6113
SEGMENT_PERSON_NAME	Endre Majorovits
SEG_ALGORITHM	Manual via IMOD
SEG_DESC	Segmentation of centriole, microtubules, Golgi apparatus and lytic granules within the CTL and of the synaptic cleft.
SEG_FILE_NAME	/telescience/home/CCDB_DATA_USER.portal/P1694/Experiment_3423/Subject_137/Tissue_155/Microscopy_3632/CTL_ImmunSynapse_seg.tar
THRESHHOLD	.5 um $\mu\mu\mu$
THUMBNAIL	P1694/CTL_ImmunSynapse_seg_small.jpg

# USER AGREEMENT

Data Sharing and Citation Policy: The mission of the CCDB is to promote data sharing among scientists interested in cellular and subcellular anatomy and in developing computer algorithms for 3D reconstruction and modeling of such data. Data sets may be viewed or shared at the discretion of the author of the data. In some cases, the data may be freely viewed and downloaded without contacting the original author while in other cases, permission of the author may have to be obtained prior to downloading the data. In either case, failure to cite or give proper credit to the original authors who collected these data in subsequent published articles or presentations is a material breach of this User Agreement. CCDB requires all researchers re-analyzing these published data via the CCDB access to reference the original published article and the CCDB. An example of an appropriate acknowledgement is provided on the CCDB web site. CCDB is not in a position to police every intended use of these data. The scientific community will self-police the compliance of this contractual obligation.

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# USER NOTIFICATION

For large size image data, it will take several minutes to download, please be patient. Thanks!

# ACKNOWLEDGEMENT

Data used from the CCDB should be appropriately referenced, including both the author of the data and the CCDB. If the data were from a published study, the reference is included in the database record. The following reference should be cited for the CCDB:

Martone, M. E., Gupta, A., Wong, M., Qian, X., Sosinsky, G., Ludaescher, B., and Ellisman, M. H. A cell centered database for electron tomographic data. J. Struct. Biology 138: 145-155, 2002.

In addition, the support for the Cell Centered Database should be included in the acknowledgement section of any publication: The Cell Centered Database is supported by NIH grants from NCRR RR04050, RR RR08605 and the Human Brain Project DA016602 from the National Institute on Drug Abuse, the National Institute of Biomedical Imaging and Bioengineering and the National Institute of Mental Health, and NSF grants supporting the National Partnership for Advanced Computational Infrastructure NSF-ASC 97-5249 and MCB-9728338.

Maryann Martone