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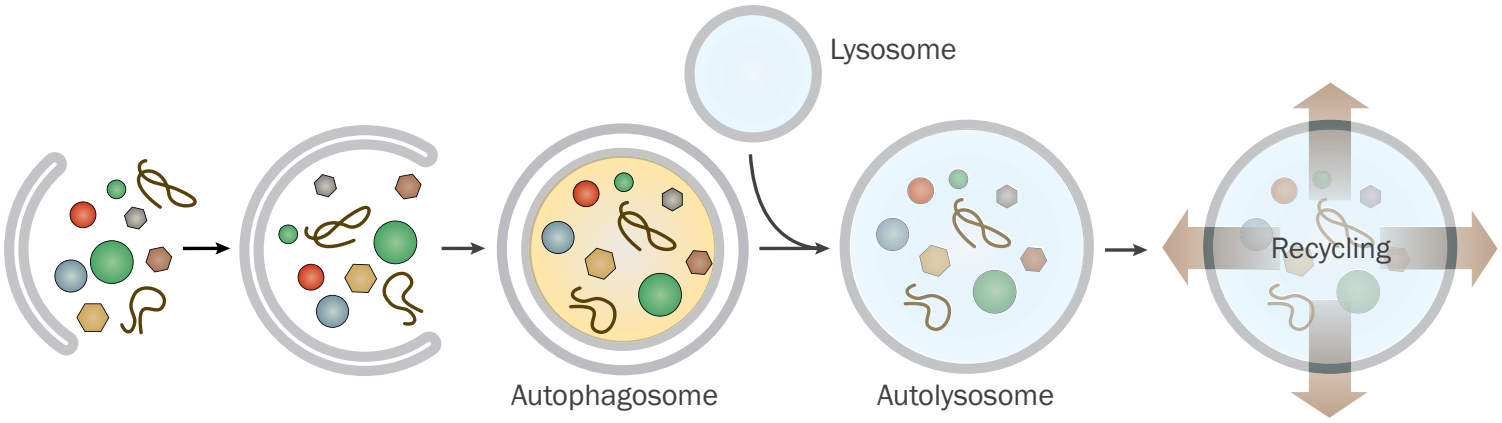
Autophagy is an exciting and rapidly expanding research area that brings new insight into biological mechanism studies as well as the promise to target autophagy-related pathways for therapeutic purposes. Bio-Techne offers a broad range of high quality products for studying all aspects of autophagy.



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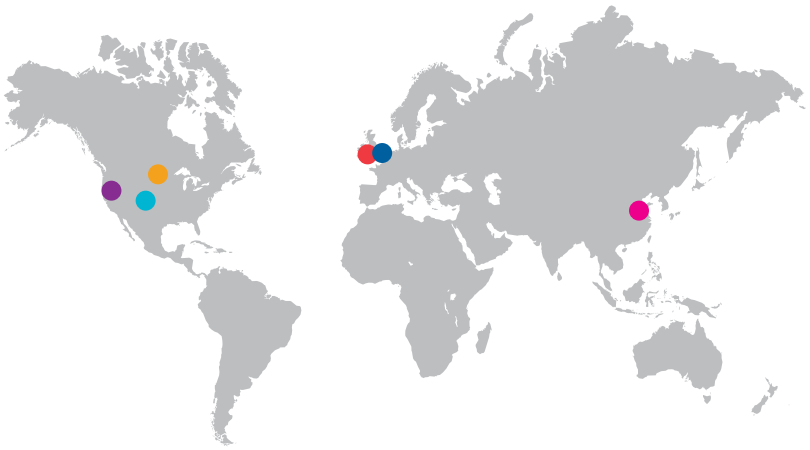

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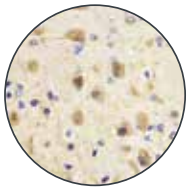
Autophagy is the process of bulk protein degradation through an autophagosomal pathway. Components of the cytoplasm are sequestered and moved into the lysosome/vacuole lumen, where they are broken down into their basic components and returned to the cytosol for reuse. Autophagy is important for differentiation, survival during nutrient deprivation and normal growth control, and is often defective in tumor cells. Autophagy is conserved from yeast to humans and is regulated by the Atg family of proteins.

Links to cancer, immunity and hypoxia have brought autophagy to the forefront of scientific studies in recent years. It now appears that autophagy's ubiquitous role in cellular maintenance may mean that it plays a role in almost all disease states.

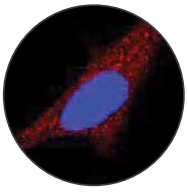
Bio-Techne offers approximately 10,000 products to meet diverse autophagy research needs, including antibodies, proteins, assay kits, lysates and small molecules. Particularly, Novus Biologicals, now a Bio-Techne brand, has been a global leading manufacturer and supplier of autophagy research antibodies for more than 15 years.

The Most Cited Autophagy Antibodies

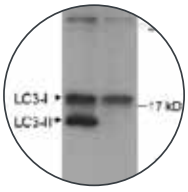
LC3 Antibodies from Novus have been cited almost 500 times in peer-reviewed journals.



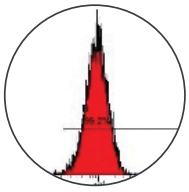
NB100-2220
IHC, rat brain



NB100-2331
ICC, HeLa cells



NB100-2331
WB, mouse ES cells



NB600-1384
FC, NTERA-2 cells

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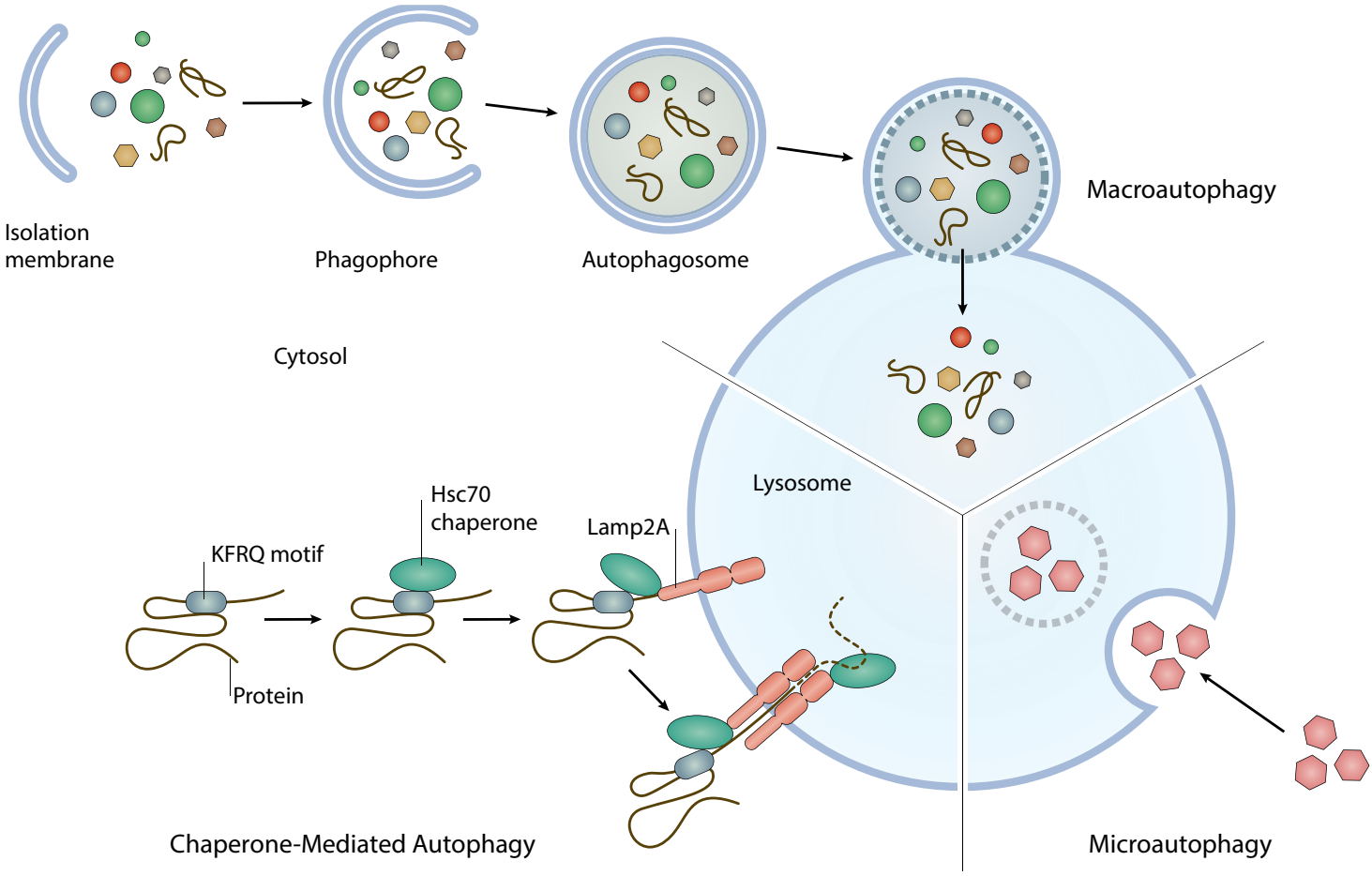
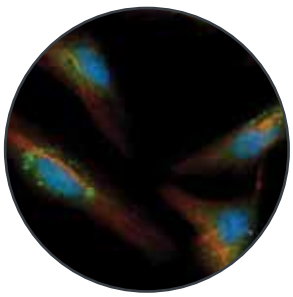
Types of Autophagy

There are three main types of autophagy in mammalian cells: macroautophagy, microautophagy and chaperone-mediated autophagy.

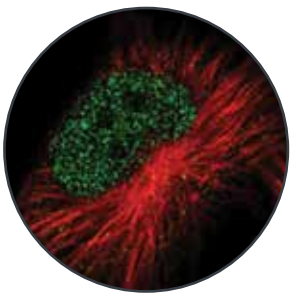


Macroautophagy

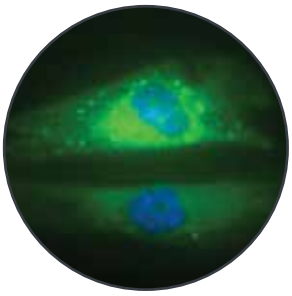
Macroautophagy involves the creation of a phagophore, leading to the formation of the autophagosome which can consume whole organelles and deliver them to the lysosome for degradation. Different from microautophagy, double-membraned structures called autophagosomes enclose cellular material and then fuse with lysosomes.



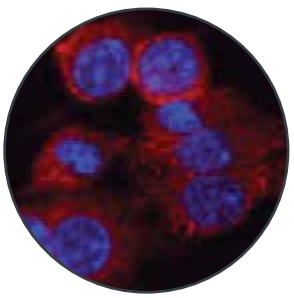
LC3, NBP1-19167
ICC, HeLa cells
(Novus)



ATG2B, NBP1-90732
ICC, U-251MG cells
(Novus)



p62/SQSTM1, NBP1-48320
ICC, HeLa cells
(Novus)



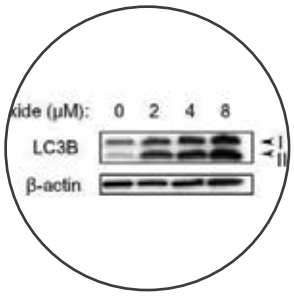
ATG4A, MAB4324
ICC, Raw 264.7 cells
(R&D Systems)

LC3

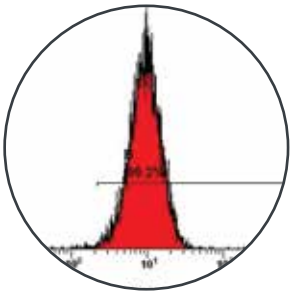
LC3 is a mammalian homolog of the yeast autophagy protein ATG8, originally identified as microtubule associated protein 1 light chain 3 (MAPLC3). LC3 is expressed as three splice variants (LC3A, LC3B and LC3C). Each of these splice variants exhibits different tissue distributions and is processed into two different post-translationally modified forms, LC3-I and LC3-II. LC3-I is found in the cytosol while LC3-II localizes to autophagasome membranes. LC3-II is the first mammalian protein identified that specifically associates with the autophagosome membranes. In addition to acting as a marker for autophagosomes, the conversion of LC3-I to LC3-II can be used to demonstrate the induction of autophagy.

LC3B, NB600-1384 (Novus)

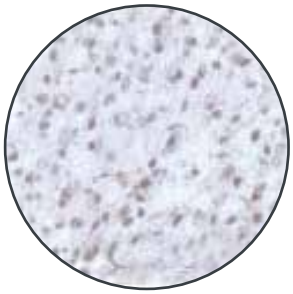
ICC, HeLa cells



WB, U87-MG cells



FC, NTERA-2 cells



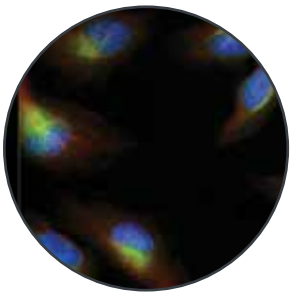
IHC, glioblastoma tissue

Product Type	Target	Catalog #	Species	Clonality	Applications	Brand
Antibodies	LC3	NB100-2331	H, M, R +	Poly	WB, SW, FC, ICC, IHC, IP	Novus Biologicals
		NBP1-19167	H, M, R +	Poly	WB, SW, FC, ICC, IHC	Novus Biologicals
		NBP1-78964	H, M, R +	Poly	WB, ICC, IHC	Novus Biologicals
		NBP2-24392	H, M, R +	Poly	WB, IHC	Novus Biologicals
	LC3B	NB100-2220	H, M, R +	Poly	WB, SW, ICC, IHC, IP	Novus Biologicals
		NB600-1384	H, M, R +	Poly	WB, SW, EM, FC, ICC, IHC	Novus Biologicals
	LC3C	NBP2-36664	H	Poly	WB, ICC, IHC	Novus Biologicals
		NB110-74806	H	Poly	WB, IHC	Novus Biologicals
	LC3 Antibody Pack	NB910-40435	H, M	Poly	WB, IHC	Novus Biologicals
Proteins and Peptides	LC3/MAP1LC3A	UL-430				R&D Systems
	LC3/MAP1LC3A Biotin	UL-432				R&D Systems
	LC3/MAP1LC3A Agarose	UL-435				R&D Systems
	LC3/MAP1LC3A Rhodamine110	UL-455				R&D Systems
	LC3	NB100-2220PEP				Novus Biologicals
Cell Lysates	LC3B	NBL1-12844	H		WB	Novus Biologicals
	LC3	NBP2-04906	H		WB	Novus Biologicals
	LC3	NBL1-12843	H		WB	Novus Biologicals

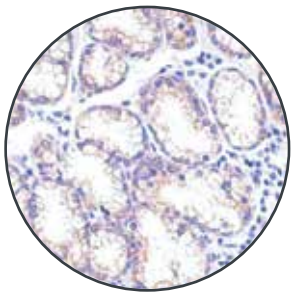
Microautophagy

Microautophagy involves the sequestering of cytosolic components at the surface of the lysosome. Compared to macroautophagy, microautophagy differs only in that the lysosome or vacuole sequesters proteins for degradation directly on their membrane surface. Therefore there are no autophagosome transport vesicles in microautophagy.

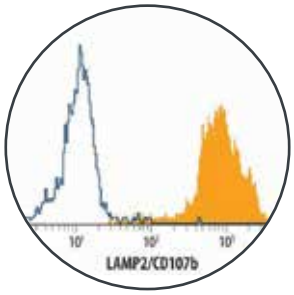
VPS41, NB100-2425
IHC, human kidney
(Novus)



Endothelial Lipase, NB400-111
ICC, HeLa cells
(Novus)



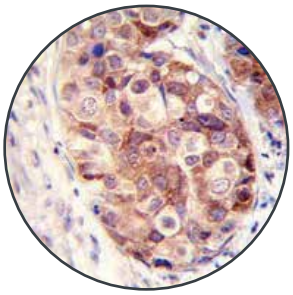
TSG101 (4A10), NB200-112
IHC, colon carcinoma
(Novus)



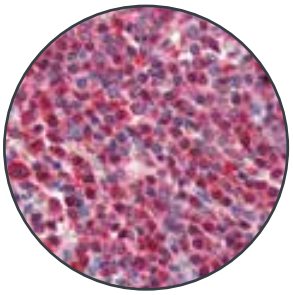
LAMP2, MAB6228
FC, HeLa cells
(R&D Systems)

Chaperone-Mediated Autophagy

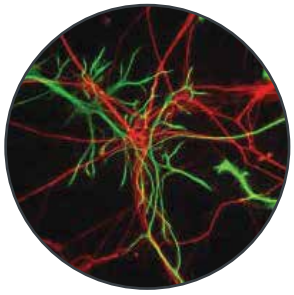
Chaperone-mediated autophagy (CMA) involves the chaperone-dependent selection of soluble cytosolic proteins which are then targeted to lysosomes, before directly translocated across the lysosome membrane for degradation. The unique features of chaperone-mediated autophagy are the selectivity on the proteins that are degraded by this pathway and the direct shuttling of these proteins across the lysosomal membrane without the requirement for the formation of additional vesicles.



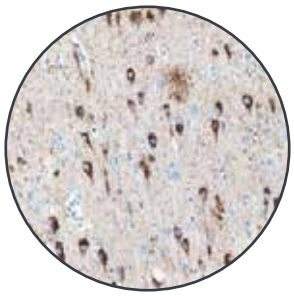
Hsp90A, NB120-2928
IHC, breast carcinoma
(Novus)



Hsc70/ Hsp73, NBP1-97868
IHC, human spleen
(Novus)



GFAP, NB300-141
ICC, rat neurons
(Novus)



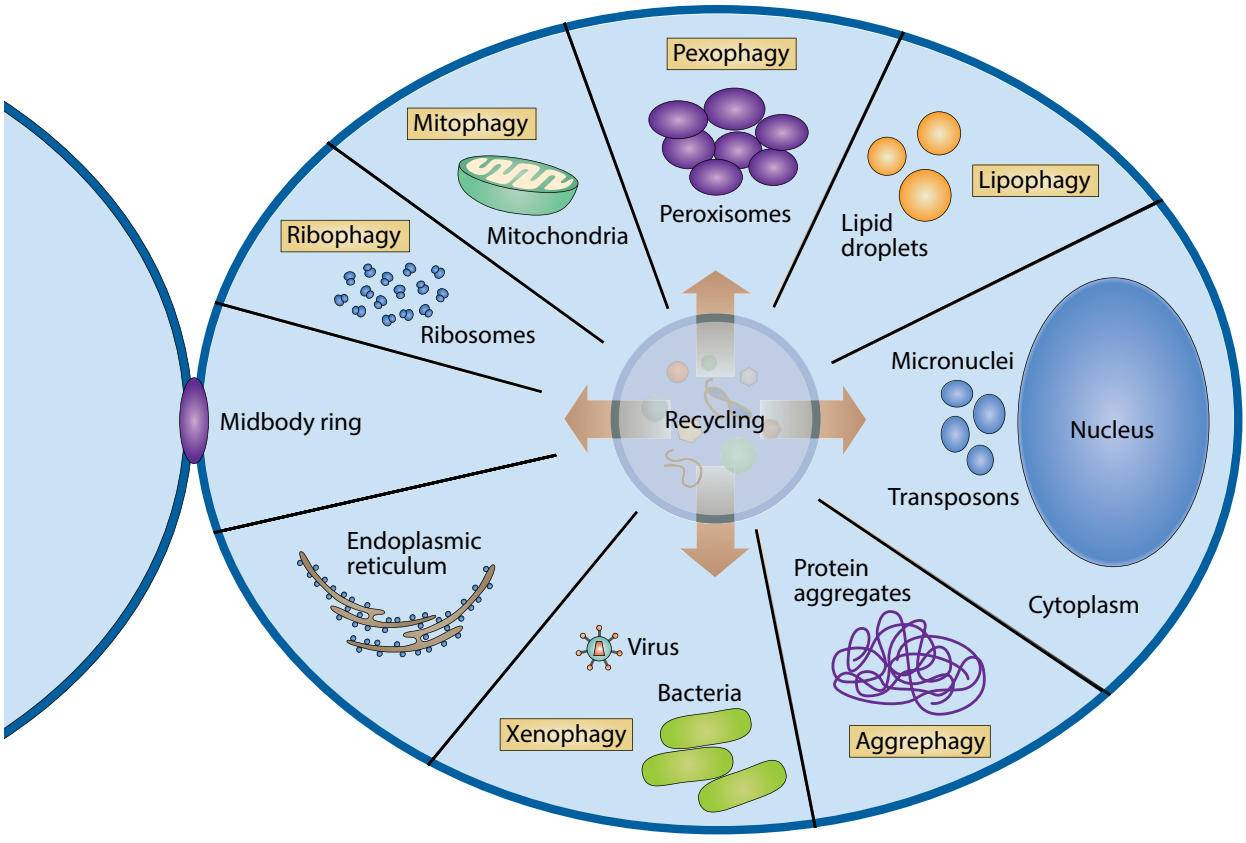
Tau, MAB3494
IHC, human Alzheimer's brain
(R&D Systems)

Components of Chaperone-Mediated Autophagy

Components of CMA	Antibody Target	Catalog #	Species	Clonality	Applications	Brand
Substrates	Aldolase B	NBP2-15345	H, M, R	Poly	WB, ICC, IHC	Novus Biologicals
	Fos	AF7254	H	Poly	WB	R&D Systems
	Eps8	NBP2-27300	H	Mono	WB, IHC	Novus Biologicals
	Pax2	NB600-1455	H	Poly	WB, ICC, IHC	Novus Biologicals
	MEF2D	NBP2-17261	H	Poly	WB	Novus Biologicals
	RCAN1	NBP1-46852	H, M	Poly	WB, IHC	Novus Biologicals
	α-synuclein	NBP1-26380	H, M	Mono	WB, FC, ICC, IHC	Novus Biologicals
	Tau	MAB3494	H	Mono	WB, IHC	R&D Systems
	Ubiquitin	AF7969	H	Poly	WB	R&D Systems
Chaperones	Hsp70	NBP1-77455	H, M	Poly	SW, FC, ICC, IHC	Novus Biologicals
	Hsp90 alpha	NBP1-77682	H, M	Poly	ICC, IHC	Novus Biologicals
	Hsp90 beta	NBP1-77561	H, M, R	Poly	ICC, IHC	Novus Biologicals
Receptor	LAMP2A	NBP2-22217	H	Mono	WB, SW, FC, ICC, IHC	Novus Biologicals
Regulators	GFAP	AF2594	H, R	Poly	WB, ICC	R&D Systems
	EF1 alpha	NBP1-55245	H, M, P +	Poly	WB	Novus Biologicals

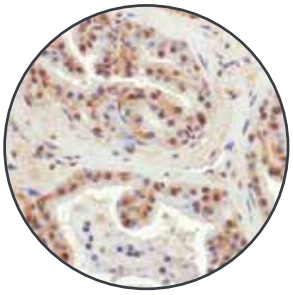
Subcellular Structure-Specific Autophagy

Depending on different subcellular structures that are specifically targeted for lysosomal degradation, autophagy processes include: mitophagy, ribophagy, lipophagy, pexophagy, aggrephagy and xenophagy.

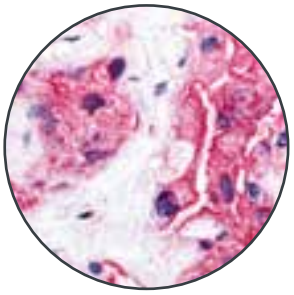


Mitophagy

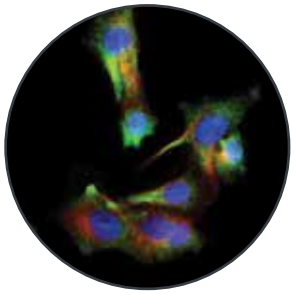
Mitophagy is a process by which mitochondria are targeted for degradation via autophagy pathway. Mitophagy is mediated by ATG32 (in yeast) and NIP3-like protein X (NIX). Mitophagy is also regulated by PINK1 and Parkin protein.



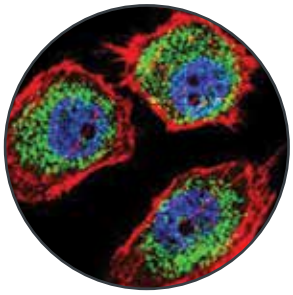
BNIP3L, NBP1-78264
IHC, mouse prostate
(Novus)



TERT, NB100-317
IHC, pancreatic carcinoma
(Novus)



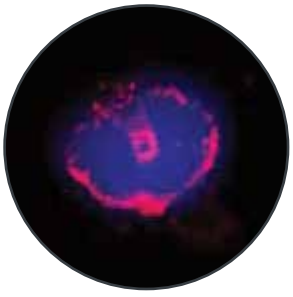
PINK1, NBP1-49678
ICC, HepG2 cells
(Novus)



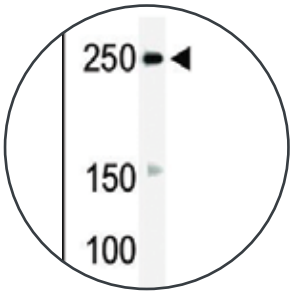
HIF-1β, NB300-525
ICC, U251 cells
(Novus)

Ribophagy

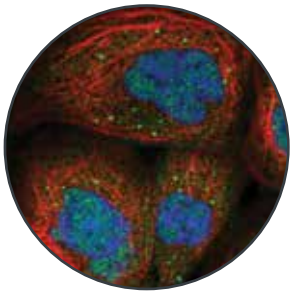
Ribophagy is a type of macroautophagy that selectively degrades ribosomes or ribosome-RNA complexes. Double-membraned autophagosomes enclose ribosomes, and then fuse with lysosomes for degradation.



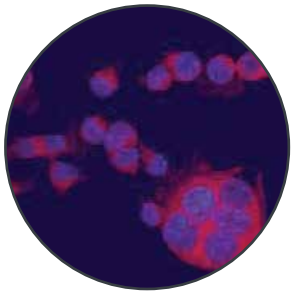
GABARAPL2, NBP2-36712
ICC, human WBCs
(Novus)



ROS, NBP2-30090
WB, HL-60 cells
(Novus)



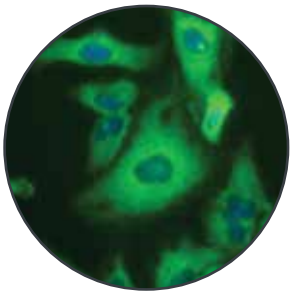
DNAI1, NBP1-84465
ICC, A-431 cells
(Novus)



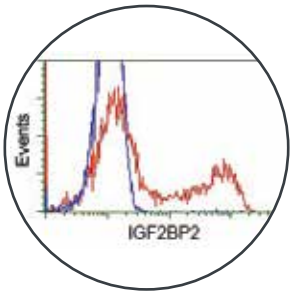
MUP-1, MAB6560
ICC, NTC-1469 cells
(R&D Systems)

Aggrephagy

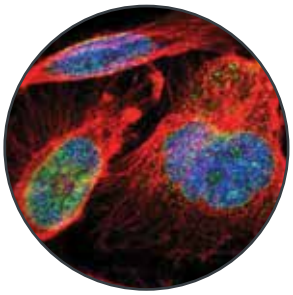
Protein aggregation is a continuous process in cells. Proteins that are damaged beyond repair can be degraded by the lysosome via autophagy. The selective degradation of protein aggregates by macroautophagy is called aggrephagy.



p62/SQSTM1, NBP1-42821
ICC, HeLa cells
(Novus)



IGF2BP2, NBP2-02627
FC, HEK293T cells
(Novus)

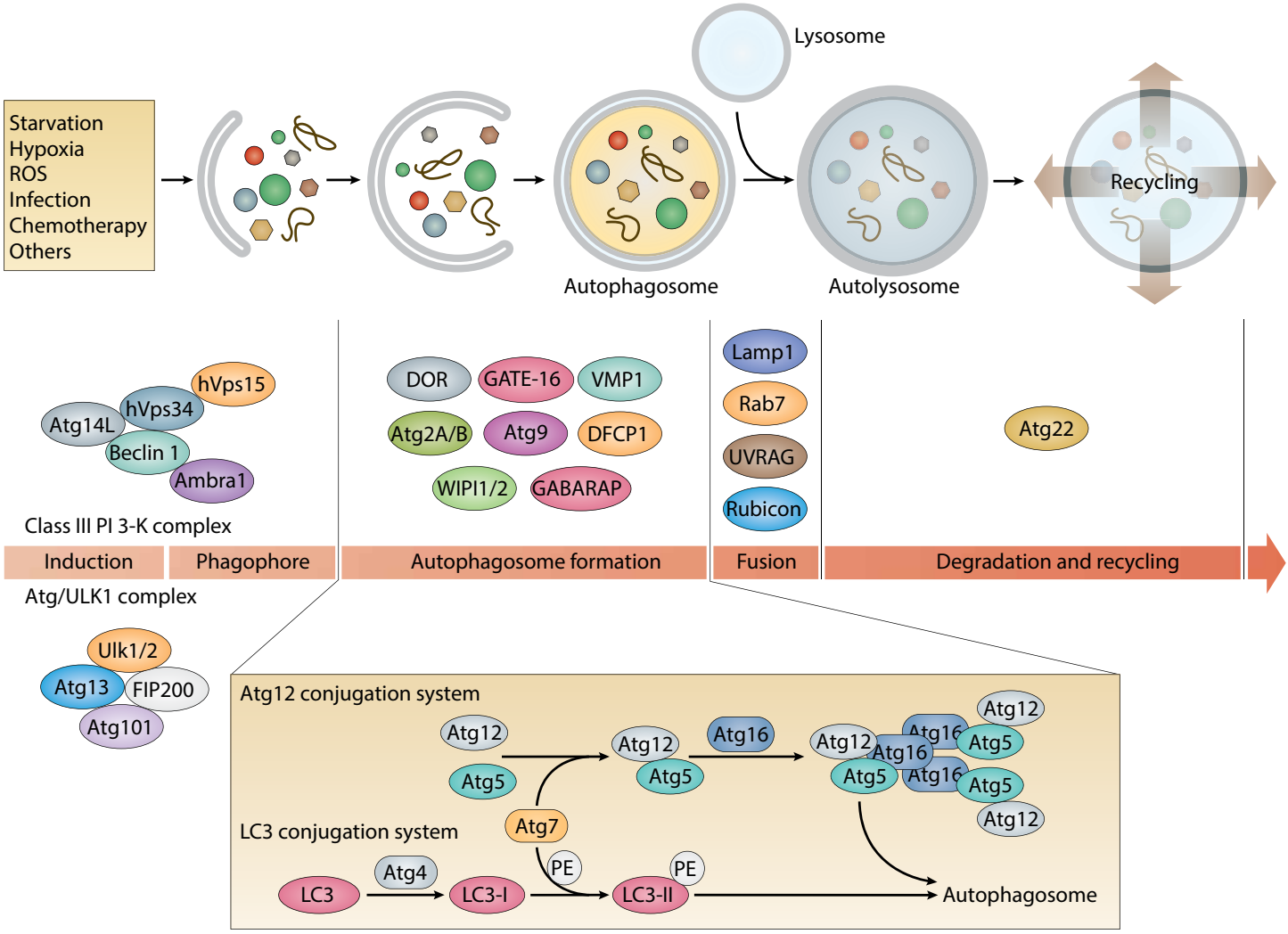


NUP62, NBP1-85091
ICC, U-251MG cells
(Novus)

SAM68, NBP1-19151
IHC, colon carcinoma
(Novus)

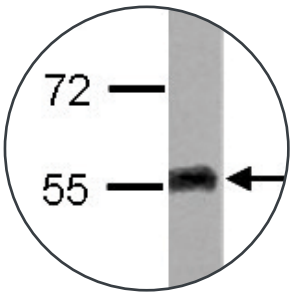
Autophagy Processes

Autophagy processes include autophagy initiation, autophagosome formation, autolysosome fusion, degradation and recycling. Major protein complexes involved in these processes include ATG1/ULK complex, PI 3 K complex, ATG8/Ubl conjugation, ATG12 Ubl conjugation, and ATG9 cycling system.

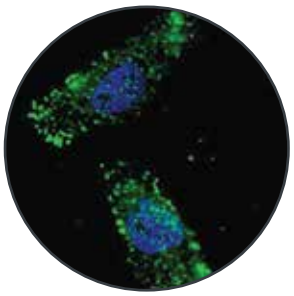


Autophagy Initiation

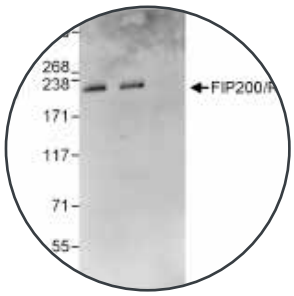
Autophagy initiation involves ATG1/ULK complex, PI3K complex, LC3 recruitment and p62 binding.



ATG13, NBP2-15502
WB, mouse brain
(Novus)



ULK1, NBP2-29922
ICC, U251 cells
(Novus)



FIP200, NB100-77279
WB, HeLa cells
(Novus)

ATG101, NBP1-88877
IHC, human skeletal muscle
(Novus)

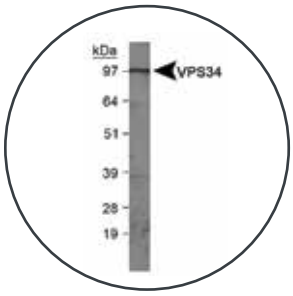
ATG1/ULK Complex

Target	Catalog #	Species	Clonality	Applications	Brand
ULK1	NBP2-24738	H, M, Pr	Poly	WB, IHC	Novus Biologicals
ULK2	NBP1-33136	H, M	Poly	WB, ICC, IHC	Novus Biologicals
Phospho-ATG13 (S318)	NBP2-19127	H	Poly	WB, ELISA	Novus Biologicals
FIP200	NB100-77279	H, M	Poly	WB, IP	Novus Biologicals
ATG101	NBP1-88877	H	Poly	WB, IHC	Novus Biologicals

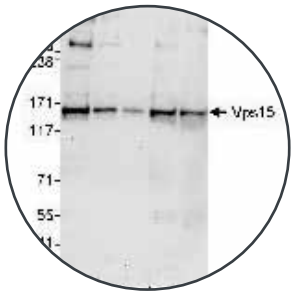
PI3K Complex

Beclin 1 and Beclin 2

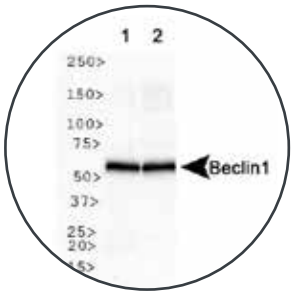
Beclin 1 is a subunit of the Class III PI 3 K complex. The binding of Beclin 1 to the pre-autophagosomal structure initiates the formation of the autophagosome and is therefore required for autophagy. Beclin 1 was the first mammalian gene to be identified that mediates autophagy; it also has tumor suppressor and antiviral functions. Beclin 2 is a novel coiled-coil protein related to Beclin 1. It is thought to interact with Bcl-2, an anti-apoptotic protein, and is believed to function in autophagy.



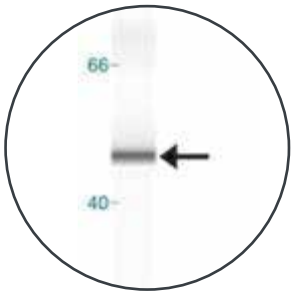
VPS34, NB110-87320
WB, HepG2 cells
(Novus)



VPS15, NBP1-30463
WB, HeLa, 293T & NIH3T3 cells
(Novus)



Beclin 1, NB500-249
WB, human & mouse brains
(Novus)



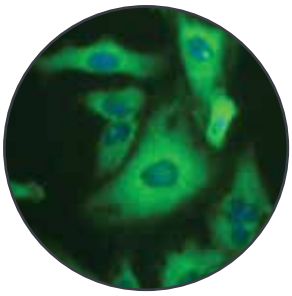
Beclin 2, NB110-60984
SW, HeLa cells
(Novus)

Antibody Target	Catalog #	Species	Clonality	Applications	Brand
ATG14L	NBP2-36445	H, M, R	Poly	WB, ELISA, ICC	Novus Biologicals
VPS34	NB110-87320	H, M, R +	Poly	WB, SW, ICC	Novus Biologicals
PIK3R4 (VPS15)	NBP1-30463	H, M	Poly	WB, ICC, IP	Novus Biologicals
	MAB6104	H	Mono	WB	R&D Systems
Ambra1	NBP1-07124	H, M, R	Poly	WB, ELISA, ICC, IHC	Novus Biologicals
Beclin 1	NB500-249	H, M, R	Poly	WB, SW, ICC, IHC, IP	Novus Biologicals
	AF5295	H, M	Poly	WB, ICC	R&D Systems
	MAB5295	H, M, R	Mono	WB	R&D Systems
Beclin 2	NB110-60984	H	Poly	WB, SW	Novus Biologicals

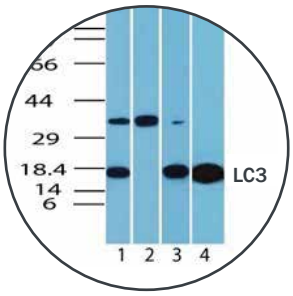
Autophagosome Formation

The formation of autophagosomes involves ATG12 Ubiquitin-like (Ubl) conjugation and LC3/ATG8 conjugation.

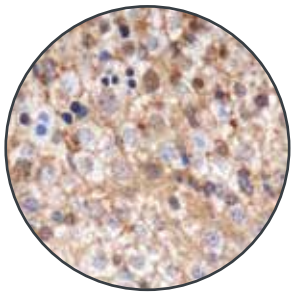
LC3/ATG8 Ubl conjugation



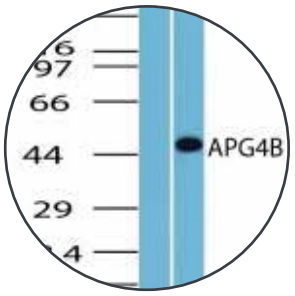
p62/ SQSTM1, NBP1-42821
ICC, HeLa cells
(Novus)



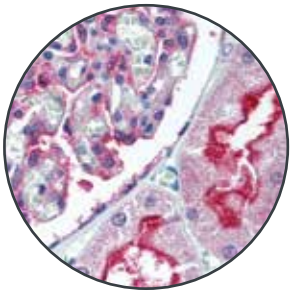
LC3, NBP2-24394
WB, brain tissues
(Novus)



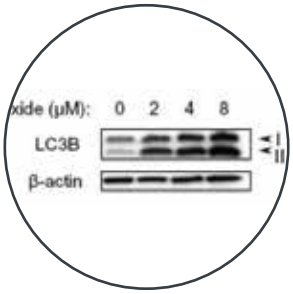
GABARAP, NBP1-97416
IHC, mouse liver
(Novus)



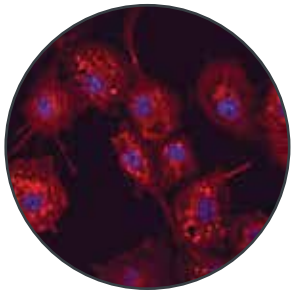
ATG4B, NBP2-24735
WB, Jurkat cells
(Novus)



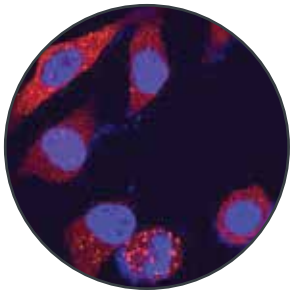
ATG7, NBP1-40039
IHC, human kidney
(Novus)



LC3B, NB600-1384
WB, U87-MG cells
(Novus)



ATG7, MAB6608
ICC, Raw 264.7 cells
(R&D Systems)

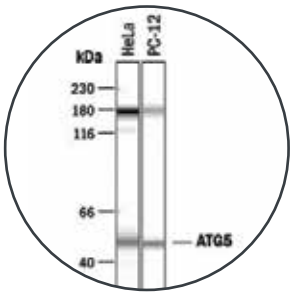


p62/SQSTM1, MAB8028
ICC, HeLa cells
(R&D Systems)

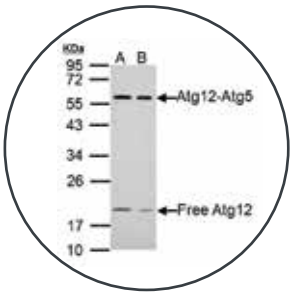
Antibody Target	Catalog #	Species	Clonality	Applications	Brand
p62/ SQSTM1	NBP1-42821	H, M, R	Poly	WB, ICC	Novus Biologicals
	MAB8028	H, M, R	Mono	WB, SW, ICC	R&D Systems
	BAM8028	H, M, R	Mono	ICC	R&D Systems
	IC8028G	H, M, R	Mono	ICC	R&D Systems
LC3	NB100-2220	H, M, R +	Poly	WB, SW, ICC, IHC, IP	Novus Biologicals
GABARAP	NBP1-97416	M	Poly	IHC	Novus Biologicals
ATG4B	NBP2-24709	H, M, R	Poly	WB, IHC	Novus Biologicals
	MAB5279	H	Mono	WB, IP	R&D Systems
ATG4A	AF4324	H	Poly	WB, IP	R&D Systems
	MAB4324	H, M	Mono	WB, ICC, IP	R&D Systems
ATG7	NBP1-95872	H, M, R	Mono	WB, ICC	Novus Biologicals
	MAB6608	H, M	Mono	WB, SW, ICC, IHC	R&D Systems
LC3B	NB600-1384	H, M, R +	Poly	WB, SW, EM, FC, ICC, IHC	Novus Biologicals
ATG3	AF5450	H, M, R	Poly	WB, ICC	R&D Systems

ATG12 Ubl conjugation

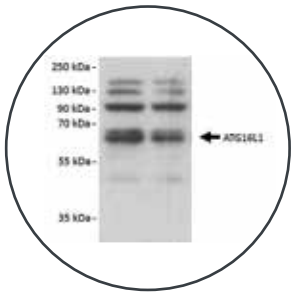
ATG5 complexes with ATG12 and is required for the formation of the autophagosome. ATG5 is heavily expressed in dead tumor cells, making it a marker for successful anti-cancer therapies. The ATG12-ATG5-ATG16L complex is essential for the elongation of autophagic isolation membranes.



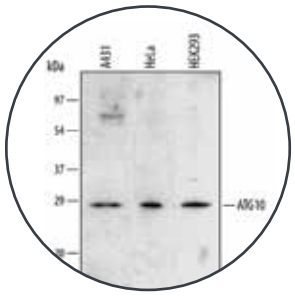
ATG5, MAB5294
SW, HeLa & PC-12 cells
(R&D Systems)



ATG12, NBP2-15501
WB, 293T & A431 cells
(Novus)



ATG16L1, NB110-60928
WB, HCT116 cells
(Novus)

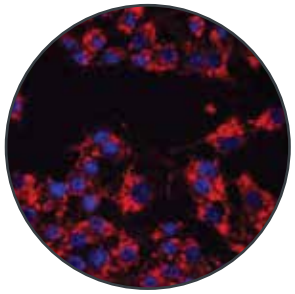


ATG10, AF5464
WB, A431, HeLa & HEK293 cells
(Novus)

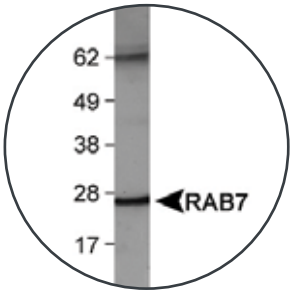
Antibody	Catalog #	Species	Clonality	Applications	Brand
ATG5	NB110-53818	H, M, R +	Poly	WB, SW, ICC, IHC, IP	Novus Biologicals
	MAB5294	H, M, R	Mono	WB, SW, IHC	R&D Systems
ATG12	NBP2-15501	H, M, R	Poly	WB, ICC, IHC	Novus Biologicals
	MAB6807	H, M	Mono	WB, ICC	R&D Systems
ATG16L1	NB110-60928	H, M, R +	Poly	WB, EM, IHC	Novus Biologicals
ATG10	AF5464	H	Poly	WB	R&D Systems

Autolysosome Fusion

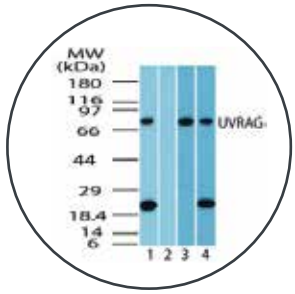
The direct fusion of autophagosomes with lysosomes produces autolysosomes. The proteins involved in this process include LAMP1, Rab7, UVRAG and Rubicon.



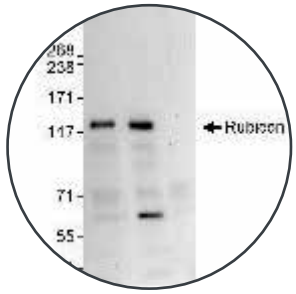
LAMP1, AF4320
ICC, RAW 264.7 cells
(Novus)



Rab7, NBP1-05048
WB, NIH 3T3 cells
(Novus)



UVRAG, NBP2-24482
WB, heart tissues
(Novus)



Rubicon, NBP1-30461
WB, HeLa cells
(Novus)

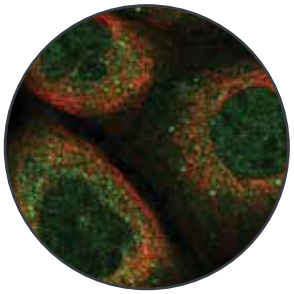
Learn more about Autophagy Research Tools from Bio-Techne at:

Novus Biologicals: novusbio.com/research-areas/autophagy
R&D Systems: rndsystems.com/autophagy
Tocris Bioscience: tocris.com/autophagy

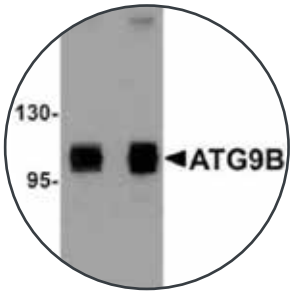
Degradation and Recycling

ATG9 cycling system

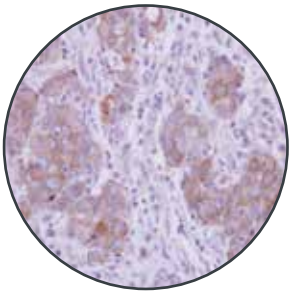
ATG9 is the only integral membrane protein required for autophagosome formation, and is considered a membrane carrier in autophagy-related pathways. It is regulated via ATG1 and is found migrating between mitochondria and the pre-autophagosomal structure.



ATG2A, NBP1-83009
ICC, A-431 cells
(Novus)



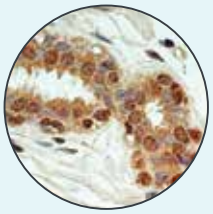
ATG9B, NBP1-77169
WB, HeLa cells
(Novus)



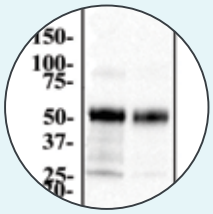
WIPI 2, NBP2-20906
IHC, breast cancer
(Novus)

ATG9A, NB110-56893
IHC, mouse intestine
(Novus)

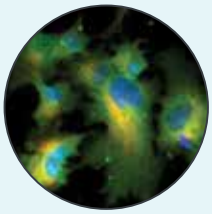
As a leading supplier of Autophagy research antibodies, Bio-Techne always stays at the forefront of this exciting research area. Here are a few examples of newly developed Autophagy-related antibodies:



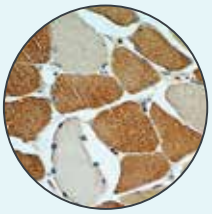
NALP6, NBP2-31372
IHC, normal breast tissue
(Novus)



PPAR-γ NBP2-22106
WB, adipose & adrenal
(Novus)



MCT1, NBP1-59656
ICC, HeLa cells
(Novus)

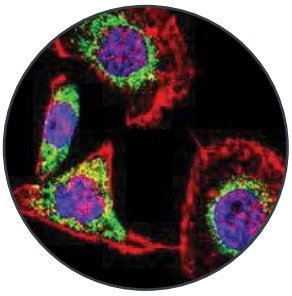


TREX1, NBP2-29617
IHC, skeletal muscle
(Novus)

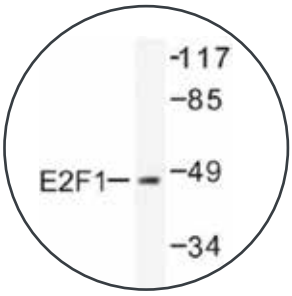
Regulation of Autophagy

Transcriptional regulation of autophagosome marker LC3

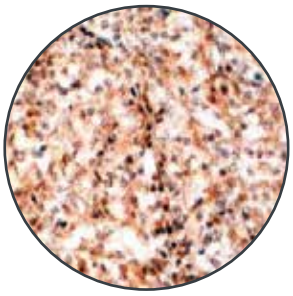
As an autophagosome marker, LC3 is considered the only well-characterized protein that is specifically localized to autophagic structures, throughout the process from phagophore to lysosomal degradation. At the transcriptional level, there are several factors that regulate (either up-regulate or down-regulate) the expression of LC3.



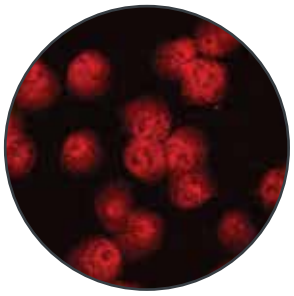
SREBP2, NB100-74543
ICC, HeLa cells
(Novus)



E2F1, NB100-92030
WB, HeLa cells
(Novus)



TFEB, NB100-1030
IHC, human kidney cancer
(Novus)



CHOP, MAB7224
ICC, Jurkat cells
(R&D Systems)

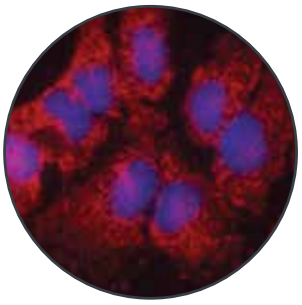
Transcription Factor	Regulation of LC3	Autophagy Effect	Catalog #	Species	Clonality	Applications	Brand
ATF4	Up-regulation	Increased	MAB7218	H	Mono	WB, ICC	R&D Systems
			NB100-81802	H	Poly	WB, IHC	Novus Biologicals
CHOP	Up-regulation	Increased	NB600-1335	H, M, R +	Mono	WB, SW, GS, ICC, IHC, IP	Novus Biologicals
			MAB7224	H	Mono	ICC	R&D Systems
E2F1	Up-regulation	Increased	NB600-210	H, M	Mono	WB, ICC, IHC, IP	Novus Biologicals
			AF4825	H	Poly	WB, IHC	R&D Systems
FOXO1	Up-regulation	Increased	NBP2-31376	H	Mono	WB, SW, ICC, IHC	Novus Biologicals
			MAB5939	H	Mono	ICC	R&D Systems
GATA1	Up-regulation	Increased	AF1779	H	Poly	WB	R&D Systems
			MAB1779	H	Mono	WB, ICC	R&D Systems
JUN	Up-regulation	Increased	AF2670	H	Poly	WB	R&D Systems
			NB110-55569	H, M, R	Mono	WB, FC, ICC, IHC, IP	Novus Biologicals
SREBP2	Up-regulation	Increased	AF7119	H	Poly	WB, CHIP, ICC	R&D Systems
			MAB7119	H	Mono	WB, ICC, IHC	R&D Systems
TFEB	Up-regulation	Increased	NB100-1030	H	Poly	WB, IHC, ELISA	Novus Biologicals
			NBP2-12758	H	Poly	WB, IP	Novus Biologicals
ZKSCAN3	Down-regulation	Decreased	NBP1-31566	H	Poly	WB, ICC, IHC	Novus Biologicals

Protein Regulators

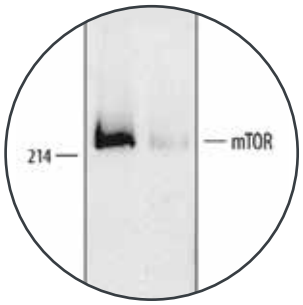
In addition to the transcriptional regulation of autophagy via LC3, there are many other proteins such as mTOR that regulate autophagy pathways.

mTOR

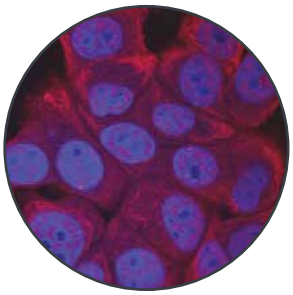
mTOR (mammalian Target of Rapamycin) is an evolutionarily-conserved protein kinase. As a central regulator of cell growth, mTOR plays a key role at the interface of the pathways that coordinate regulation of the balance between cell growth and autophagy in response to nutritional status, growth factor and stress signals.



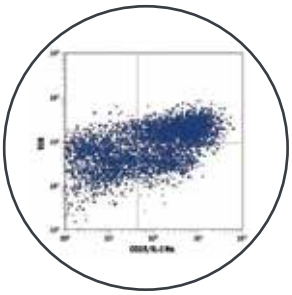
mTOR, NB100-240
ICC, HeLa cells
(Novus)



mTOR (pSer2448), AF1665
WB, DU145 cells
(Novus)



mTOR, MAB1537
ICC, MCF-7 cells
(R&D Systems)



mTOR (w/ PE), IC1537P
FC, human PBMCs
(R&D Systems)

Negative Regulators of Autophagy

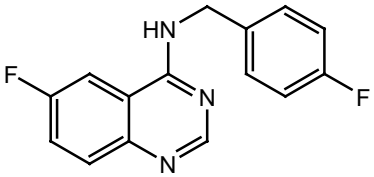
Target	Catalog #	Species	Clonality	Applications	Brand
mTOR	AF15371	H, M, R	Poly	WB, IP	R&D Systems
PI 3-kinase p110	MAB2686	H	Mono	WB	R&D Systems
PI 3-kinase p85	MAB2998	H, M, R	Mono	WB	R&D Systems
S6K	NBP2-23649	H, M, R +	Poly	WB, ELISA	Novus Biologicals
	MAB8962	H, M, R	Mono	WB, IHC, FC	R&D Systems
Phospho-S6K (T421/S424)	AF8965	H, M, R	Poly	WB, SW	R&D Systems
Phospho-S6K (T389)	AF8963	H, M, R	Poly	WB	R&D Systems
p38	NB100-56665	H	Poly	WB, IHC	Novus Biologicals
p38 alpha	AF8691	H, M, R	Poly	WB, SW, IHC	R&D Systems
Phospho-p38 (T180/Y182)	AF869	H, M, R	Poly	WB, SW, IHC	R&D Systems

Positive Regulators of Autophagy

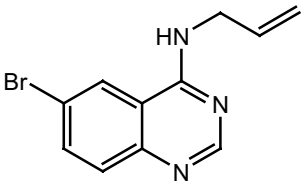
Target	Catalog #	Species	Clonality	Applications	Brand
Beclin 1	NB110-87318	H, M, Ca +	Poly	WB, SW, ICC, IHC, IP	Novus Biologicals
	NB500-266	H, M	Poly	WB, ICC	Novus Biologicals
VPS34 (Class III PI3K)	NB110-87320	H, M, R +	Poly	WB, SW, ICC	Novus Biologicals
ERK1	NB100-56376	H	Poly	WB, IHC	Novus Biologicals
TRAIL	NB100-56518	H	Mono	WB, IHC	Novus Biologicals
JNK (pan-specific)	AF1387	H, M, R	Poly	WB, IHC	R&D Systems
JNK2	NB600-1297	H	Poly	WB	Novus Biologicals
Phospho-JNK (T183/Y185)	AF1205	H, M, R	Poly	WB, SW, IHC	R&D Systems
DAPK3	AF5290	H	Poly	WB	R&D Systems
BNIP3	NB100-56150	H, R, Ch +	Poly	WB, IHC, IP	Novus Biologicals
TFEB	NB100-1030	H	Poly	WB, IHC, ELISA	Novus Biologicals
	NB100-93447	H, M, R +	Poly	WB, ELISA	Novus Biologicals

Modulate Autophagy with Small Molecules

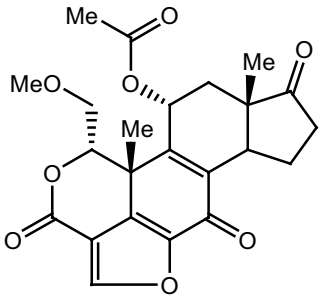
Many small molecules can induce or inhibit autophagy via a number of different targets such as mTOR, p97, and lysosomal proteases.



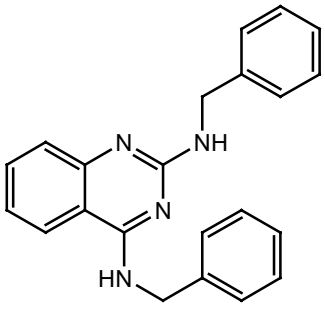
Spautin 1 (Tocris, Cat.# 5197)
USP10 and USP13 inhibitor; inhibits autophagy



SMER 28 (Tocris, Cat.# 4297)
Positive regulator of autophagy



Wortmannin (Tocris, Cat.# 1232)
Potent, irreversible inhibitor of PI 3-kinase



DBeQ (Tocris, Cat.# 4417)
Selective and reversible p97 inhibitor

3-Methyladenine (Tocris, Cat.# 3977)
Class III PI 3-kinase inhibitor; also inhibits autophagy

Small Molecules for Autophagy Inhibition

Name	Catalog #	Description	Brand
Bafilomycin A1	1334	H^+-ATPase (vacuolar) inhibitor	Tocris
(±)-Bay K 8644	1544	Ca^{2+}-channel activator (L-type)	Tocris
Chloroquine diphosphate	4109	Antimalarial; inhibits apoptosis and autophagy	Tocris
Concanamycin A	2656	H^+-ATPase (vacuolar) inhibitor	Tocris
DBeQ	4417	p97 inhibitor; blocks autophagosome maturation	Tocris
E 64d	4545	Cathepsin inhibitor; interferes with autolysosomal digestion	Tocris
GW 4064	2473	FXR agonist; suppresses autophagy in nutrient-deprived hepatocytes	Tocris
LY 294002 hydrochloride	1130	Selective PI 3-kinase inhibitor; inhibits autophagic sequestration	Tocris
3-Methyladenine	3977	Class III PI 3-kinase inhibitor; also inhibits autophagy	Tocris
Nocodazole	1228	Microtubule inhibitor; inhibits autophagosome-lysosome fusion	Tocris
Pepstatin A	1190	Aspartic protease inhibitor; interferes with autolysosomal digestion	Tocris
Spautin 1	5197	USP10 and USP13 inhibitor; inhibits autophagy	Tocris
Wortmannin	1232	Potent, irreversible inhibitor of PI 3-kinase; also inhibitor of PLK1	Tocris
Xanthohumol	4686	Valosin-containing protein (VCP) inhibitor	Tocris

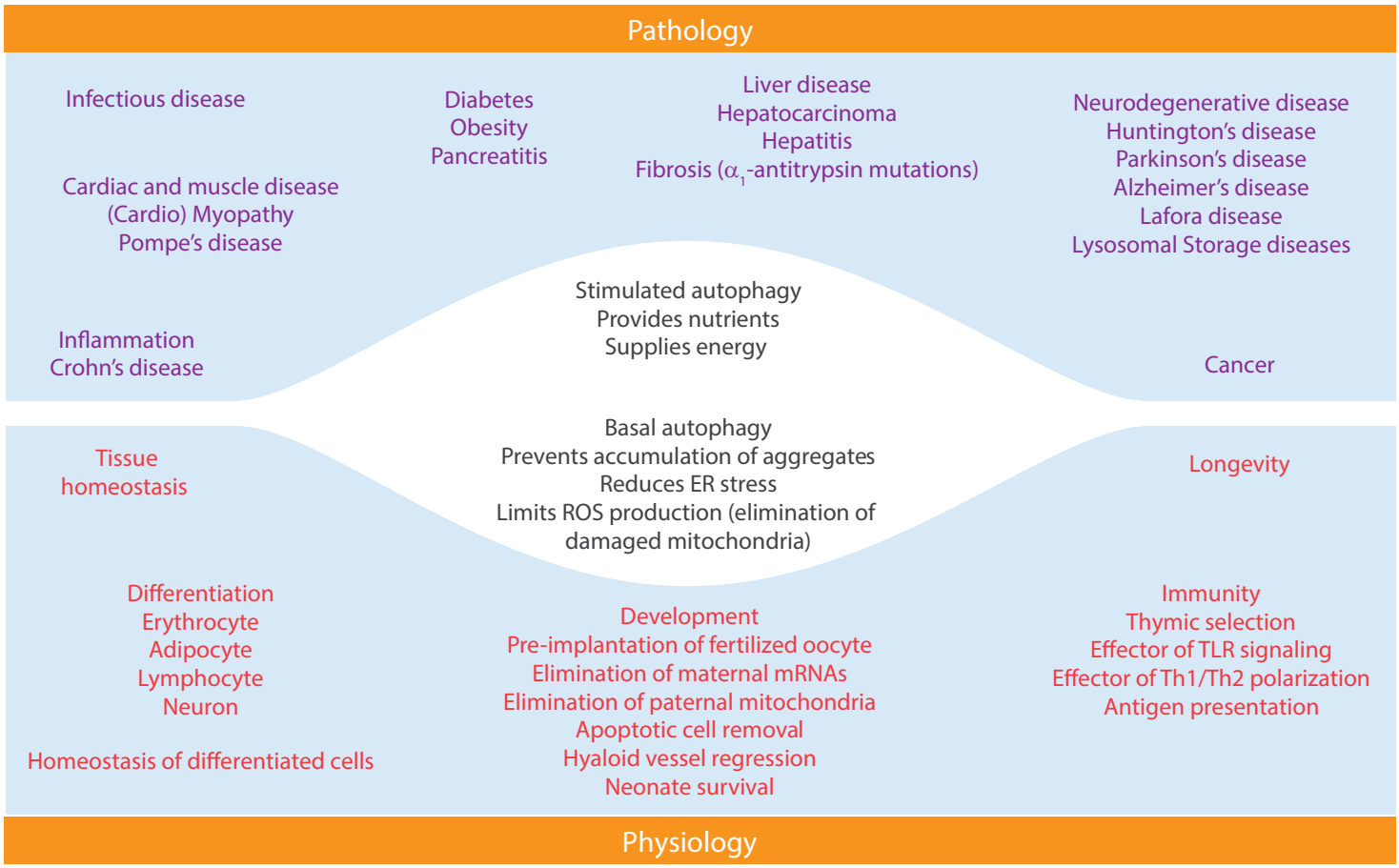
Small Molecules for Autophagy Induction

Name	Catalog #	Description	Brand
Amiodarone hydrochloride	4095	Causes mitochondrial fragmentation; stimulates autophagy	Tocris
Brefeldin A	1231	Disrupts protein translocation to Golgi	Tocris
Dexamethasone	1126	Anti-inflammatory glucocorticoid	Tocris
Dorsomorphin dihydrochloride	3093	Induces autophagy via an AMPK inhibition-independent mechanism	Tocris
EB 1089	3993	Vitamin D receptor (VDR) agonist	Tocris
FK 866 hydrochloride	4808	Non-competitive and potent NAMPT inhibitor; induces apoptosis and autophagy	Tocris
GF 109203X	0741	Protein kinase C inhibitor	Tocris
L-690,330	0681	Induces autophagy independently of mTOR inhibition	Tocris
NF 449	1391	Highly selective P2X1 antagonist	Tocris
Nimodipine	0600	Ca^{2+} channel blocker (L-type)	Tocris
3-Nitropropionic acid	4849	Irreversible mitochondrial respiratory complex II inhibitor	Tocris
PI 103 hydrochloride	2930	Inhibitor of PI 3-kinase, mTOR and DNA-PK	Tocris
Rapamycin	1292	mTOR inhibitor; immunosuppressant	Tocris
Rilmenidine hemifumarate	0790	α2-adrenergic agonist; also I1-imidazoline binding site selective ligand	Tocris
Rottlerin	1610	Reported PKCδ inhibitor	Tocris
Salirasib	4989	Ras inhibitor; also induces autophagy	Tocris
SMER 28	4297	Positive regulator of autophagy	Tocris
Thapsigargin	1138	Potent inhibitor of SERCA ATPase	Tocris
Torin 1	4247	Potent and selective mTOR inhibitor	Tocris
Tunicamycin	3516	Causes ER stress; can be used to induce autophagy	Tocris
Valproic acid, sodium salt	2815	Reduces inositol levels; induces autophagy	Tocris
Verapamil hydrochloride	0654	Ca^{2+} channel blocker (L-type)	Tocris
Salirasib	4989	Ras inhibitor; also induces autophagy	Tocris

Physiology and Pathology

Basal Autophagy and Induced Autophagy

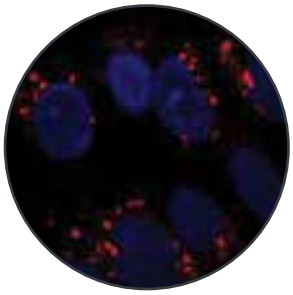
Autophagy has many essential functions in cells and tissues. Basal autophagy is essential to remove damaged proteins and organelles, reduce ER stress, and limit the production of reactive oxygen species (ROS). Induced autophagy is important to provide nutrients and building blocks during periods of starvation. Autophagy is essential during the development and differentiation of many cell types, as well as in maintaining tissue homeostasis. Autophagy also plays an essential role during immunity. It is not surprising that dysregulation of autophagy has been implicated in the pathology of many diseases including cancer.



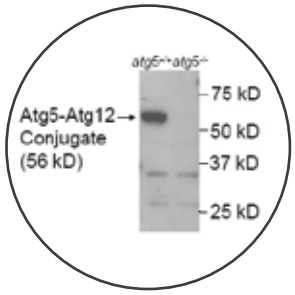
Autophagy in Immunity

Autophagy is well integrated into immune regulation systems. Autophagy facilitates the recognition of infected cells by innate immune effectors. For example, although ATG3, ATG5 and ATG7 were found dispensable to be for the development of thymocytes, their absence impairs the survival and proliferation of peripheral T cells.

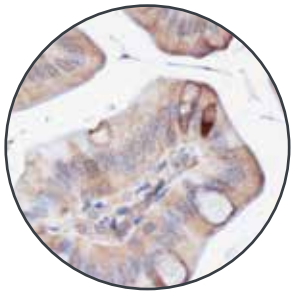
ATG5,NB110-53818 (Novus)



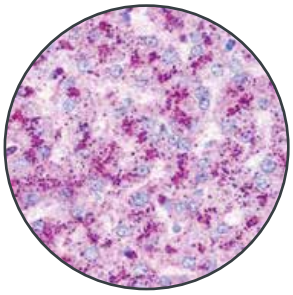
ICC, SH-SY5Y cells



WB, mouse ES cells



IHC, mouse intestine



IHC, human hepatocytes

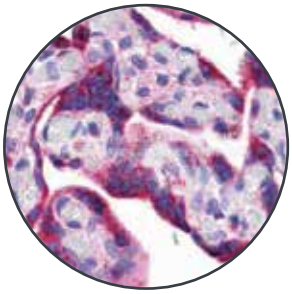
Immune Functions	Target	Catalog #	Species	Clonality	Applications	Brand
Elimination of microorganisms	SQSTM1	NBP1-48320	H, M, R	Poly	WB, SW, ICC, IHC	Novus Biologicals
	NOD2	NB100-524	H, M	Mono	WB, ICC, IHC, IP	Novus Biologicals
	ATG16L1	NB110-60928	H, M, R +	Poly	WB, EM, IHC	Novus Biologicals
Control of pro-inflammatory signaling	ATG5	NB110-53818	H, M, R +	Poly	WB, SW, ICC, IHC, IP	Novus Biologicals
	ATG12	NBP2-15501	H, M, R	Poly	WB, ICC, IHC	Novus Biologicals
		MAB6807	H, M	Mono	WB, ICC	R&D Systems
	NLRP3	NBP2-12446	H, M, R +	Poly	WB, IHC	Novus Biologicals
		MAB7578	H, M	Mono	WB, FC, ICC	R&D Systems
	DICER	NB200-591	H, M	Poly	WB, IHC	Novus Biologicals
Regulation of adaptive immunity	IL-1α	AF-200-NA	H	Poly	WB, B/N, ICC	R&D Systems
		AF-400-NA	M	Poly	WB, B/N, IHC	R&D Systems
	IL-1β	AF-401-NA	M	Poly	WB, B/N, ICC, IHC	R&D Systems
		AF-201-NA	H	Poly	WB, B/N, ICC	R&D Systems
		NB600-633	H, M, Ba +	Poly	WB, ELISA, EM, IHC, IP	Novus Biologicals
Secretion of immune mediators	HMGB1	NB100-2322	H, M, R +	Poly	WB, SW, FC, ICC, IHC	Novus Biologicals
		AF1690	H, M	Poly	WB	R&D Systems
	NOX2	NBP1-41012	H	Mono	WB, ELISA, FC, ICC, IHC	Novus Biologicals
	TRAF6	AF3284	H	Poly	WB	R&D Systems
		NB100-56436	H, M	Poly	WB	Novus Biologicals

Autophagy and Cancer

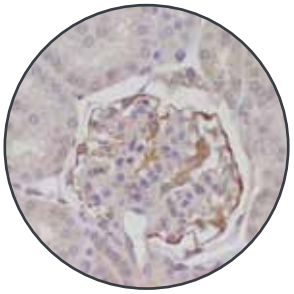
The role of autophagy in cancer is complex. During tumor initiation, autophagy acts as a barrier to cell transformation by reducing cell proliferation and DNA damage. However, during tumor progression, high levels of autophagy increase cancer cell survival. Cancers subsequently become dependent on autophagy to sustain cell growth.

Autophagy Proteins as Tumor Suppressors

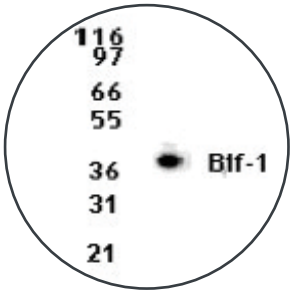
Several lines of evidence have supported the view of autophagy as a novel mechanism of tumor suppression. Several autophagy proteins such as Beclin 1, Bif-1 and UVRAG have been found to function as tumor suppressors. Many anti-cancer agents such as tamoxifen and rapamycin, acting as potent inducers of autophagy, further support the prevailing view of autophagy as a mechanism of tumor suppression.



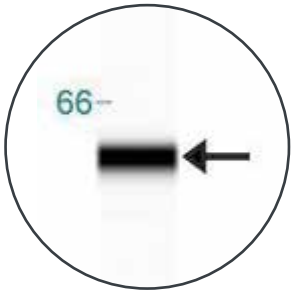
ATG5, NBP1-59085
IHC, human placenta
(Novus)



Beclin 1, NB500-249
IHC, mouse kidney
(Novus)



Bif-1, NBP2-24733
WB, Jurkat cells
(Novus)



Beclin 1, NB110-87318
SW, HeLa cells
(Novus)

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Biochemical Analysis of Autophagy

Product Type	Product Name	Catalog #	Brand
Enzymes	ATG7 isoform 1	E-318	R&D Systems*
	ATG4B	E-400	R&D Systems
	ATG3	E2-670	R&D Systems
Proteins	pro-GABARAPL1	UL-400	R&D Systems
	GABARAP	UL-410	R&D Systems
	HA-GABARAP	UL-440	R&D Systems
	GABARAP Biotin	UL-412	R&D Systems
	GABARAP Fluorescein	UL-414	R&D Systems
	GABARAP Agarose	UL-415	R&D Systems
	GABARAP Rhodamine	UL-416	R&D Systems
	GATE16	UL-420	R&D Systems
	GATE16 Rhodamine	UL-426	R&D Systems
	LC3/MAP1LC3A	UL-430	R&D Systems
	LC3/MAP1LC3A Biotin	UL-432	R&D Systems
	LC3/MAP1LC3A Agarose	UL-435	R&D Systems
	LC3/MAP1LC3A Rhodamine110	UL-455	R&D Systems
Peptides	ATG5 peptide	NB110-53818PEP	Novus Biologicals
	ATG16L1	NB110-60928PEP	Novus Biologicals
	ATG9A	NB110-56893PEP	Novus Biologicals
	Beclin 1	NB500-249PEP	Novus Biologicals
	LC3B	NB100-2220PEP	Novus Biologicals
	p62/SQSTM1	NBP1-42821PEP	Novus Biologicals

* R&D Systems Ubiquitin and Ubiquitin-related products are powered by Boston Biochem.

Species Key:

H - Human, M - Mouse, R - Rat, B - Bovine, Ba - Bacteria, Ca - Canine, Ch - Chicken, P - Porcine, Pr - Primate, Ra - Rabbit, X - Xenopus

Application Key:

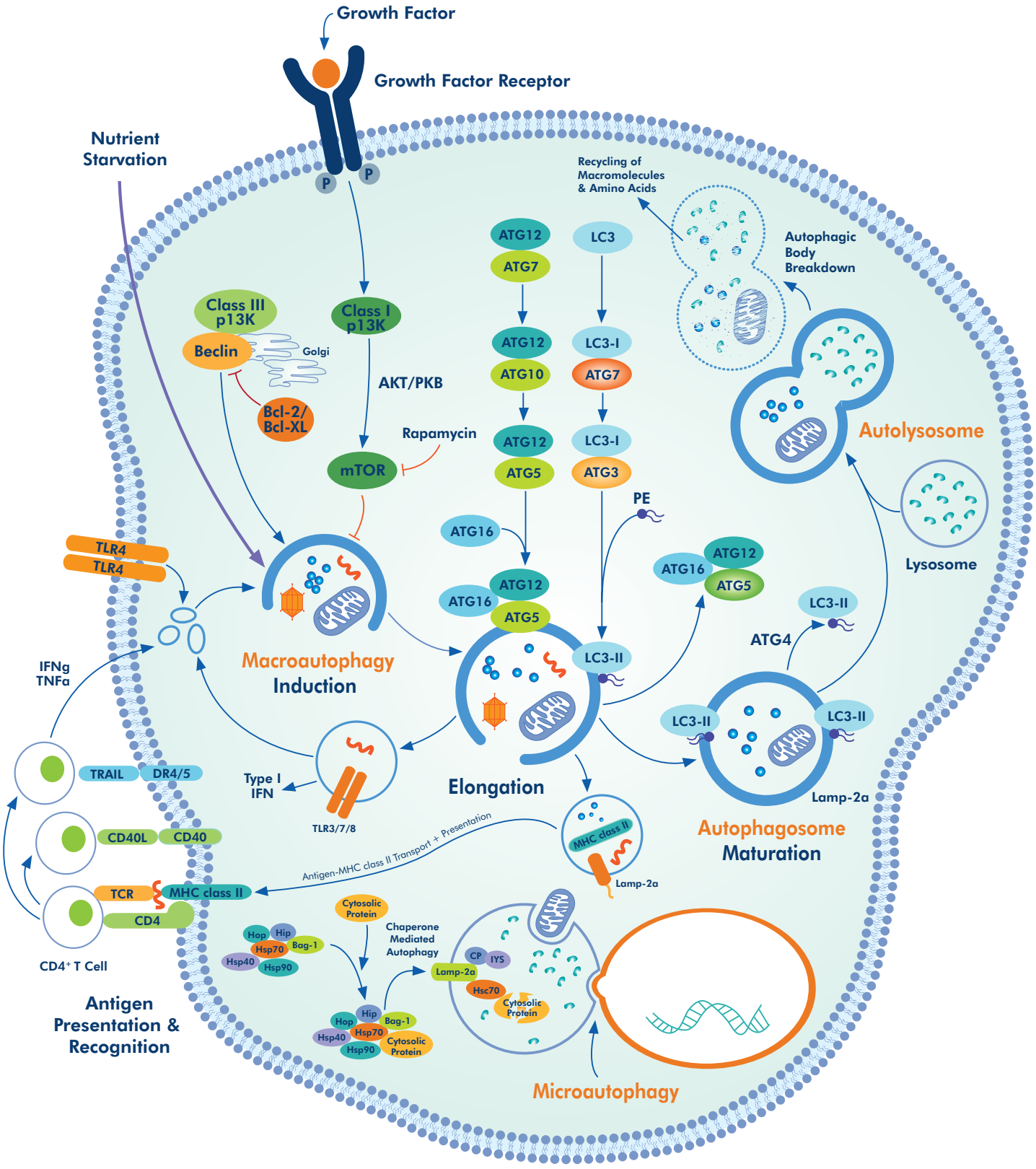
B/N - Blocking/ Neutralization, CHIP - Chromatin Immunoprecipitation, EM - Electron Microscope, FC - Flow Cytometry, GS - Gel Shift
ICC - Immunocytochemistry, IHC - Immunohistochemistry, IP - Immunoprecipitation, SW - Simple Western, WB - Western Blot

A Glimpse of Recent Citations from High Impact Journals

1. **[LC3, NB100-2220]** Wlodarska M, Thaiss CA, Nowarski R et al. NLRP6 Inflammasome Orchestrates the Coloni Host-Microbial Interface by Regulating Goblet Cell Mucus Secretion. *Cell. 2014*, PMID: 24581500. (WB, Mouse)
2. **[LC3, NB100-2220]** Chin RM, Fu X, Pai MY et al. The metabolite alpha-ketoglutarate extends lifespan by inhibiting ATP synthase and TOR. *Nature. 2014*, PMID: 24828042. (WB, Human)
3. **[LC3, NB100-2220]** Zavodszky E, Seaman MN, Moreau K et al. Mutation in VPS35 associated with Parkinson's disease impairs WASH complex association and inhibits autophagy. *Nature Commun. 2014*, PMID: 24819384. (WB,Human)
4. **[LC3, NB100-2220]** Fang EF, Scheibye-Knudsen M, Brace LE et al. Defective Mitophagy in XPA via PARP-1 Hyperactivation and NAD(+)/SIRT1 Reduction. *Cell. 2014*, PMID: 24813611. (WB, ICC/Human, Mouse, Rat)
5. **[LC3, NB100-2220]** Bingol B, Tea JS, Phu L et al. The mitochondrial deubiquitinase USP30 opposes parkin-mediated mitophagy. *Nature. 2014*, PMID: 24896179. (WB, ICC/Human)
6. **[LC3, NB100-2220]** Shanware NP, Bray K, Eng CH et al. Glutamine deprivation stimulates mTOR-JNK-dependent chemokine secretion. *Nature Commun. 2014*, PMID: 25254627.
7. **[LC3B, NB600-1384]** Meunier E, Dick MS, Dreier RF et al. Caspase-11 activation requires lysis of pathogen-containing vacuoles by IFN-induced GTPases. *Nature 2014*, PMID: 24739961. (ICC/Mouse)
8. **[LC3B, NB600-1384]** Lee JM, Wagner M, Xiao R et al. Nutrient-sensing nuclear receptors coordinate autophagy. *Nature. 2014*, PMID: 25383539.
9. **[LC3, NB100-2331]** Zhang L, Chen X, Sharma P et al. HACE1-dependent protein degradation provides cardiac protection in response to haemodynamic stress. *Nature Commun. 2014*. PMID: 24614889. (WB, Mouse)
10. **[ATG5, NB110-53818]** Bejarano E, Yuste A, Patel B et al. Connexins modulate autophagosome biogenesis. *Nature.Cell Biol. 2014*, PMID: 24705551. (WB, IP, Mouse)
11. **[ATG5, NB110-53818]** Fang EF, Scheibye-Knudsen M, Brace LE et al. Defective Mitophagy in XPA via PARP-1 Hyper activation and NAD(+)/SIRT1 Reduction. *Cell. 2014*, PMID: 24813611. (WB, Mouse)
12. **[Beclin 1, NB500-249]** Pampliega O, Orhon I, Patel B et al. Functional interaction between autophagy and ciliogenesis. *Nature. 2013*, PMID: 24089209. (ICC/Mouse)
13. **[ATF6, NBP1-40256]** Shao M, Shan B, Liu Y et al. Hepatic IRE1alpha regulates fasting-induced metabolic adaptive programs through the XBP1s-PPARalpha axis signalling. *Nature Commun. 2014*, PMID: 24670948. (WB, Mouse)
14. **[p62/SQSTM1, NBP1-49954]** Moreau K, Fleming A, Imarisio S et al. PICALM modulates autophagy activity and tau accumulation. *Nature Commun. 2014*, PMID: 25241929.
15. **[IL-1β, AF-401-NA]** Zhong Z, Zhai Y, Liang S et al. TRPM2 links oxidative stress to NLRP3 inflammasome activation. *Nature Commun. 2013*, PMID: 23511475

Find Pathways to Success in Autophagy Research

Autophagy Pathways



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