1. Phylogeny  
   MAP3K9, also known as Mixed Lineage Kinase 1 (MLK1) or PRKE1, is a serine/threonine kinase that belongs to the MAP kinase kinase kinase (MAP3K) family and is categorized specifically within the mixed‐lineage kinase (MLK) subfamily, which also comprises MLK2, MLK3, and MLK4 as well as related kinases such as the dual‐leucine‐zipper kinases (DLKs) and the zipper sterile alpha‐motif kinases (ZAK) (gallo2002mixedlineagekinasecontrol pages 1-2, gallo2002mixedlineagekinasecontrol pages 2-3).  
   MLK1 is evolutionarily conserved across metazoans, with orthologs identified in species as diverse as Drosophila melanogaster (for example, the Slpr ortholog), Caenorhabditis elegans, and mammals, which underscores its fundamental role in regulating stress and inflammatory responses (gallo2002mixedlineagekinasecontrol pages 1-2, gallo2002mixedlineagekinasecontrol pages 3-4).  
   Phylogenetic analyses based on conserved catalytic domain sequences and domain organization indicate that MLK1 evolved from an ancestral STE20-like kinase that diverged into several subfamilies during eukaryotic evolution; this diversification is supported by studies examining the kinome from yeast to humans (kyriakis2001mammalianmitogenactivatedprotein pages 1-2).  
   Furthermore, MLK1’s unique domain architecture – featuring an N-terminal Src homology 3 (SH3) domain, a serine/threonine kinase catalytic domain, leucine zipper motifs for dimerization, and a Cdc42/Rac interactive binding (CRIB) motif – reflects its evolutionary relationship with other kinases that participate in environmental stress signaling, and distinguishes it from other MAP3K families (gallo2002mixedlineagekinasecontrol pages 2-3, dan2001theste20group pages 3-4).  
   As a component of the MAP kinase cascade, MLK1 is part of an evolutionarily ancient regulatory network that can be traced back to the Last Eukaryotic Common Ancestor (LECA), in which the fundamental architecture of MAP kinase signaling was already established (kyriakis2001mammalianmitogenactivatedprotein pages 1-2).
2. Reaction Catalyzed  
   MAP3K9 catalyzes the phosphorylation of specific target MAP kinase kinases (MAP2Ks) using ATP as a phosphate donor in a classic kinase reaction.  
   The general reaction performed can be summarized by the equation: ATP + [substrate protein] (with serine/threonine) → ADP + [substrate protein] phosphorylated on serine/threonine + H⁺, where the substrate proteins are typically MAP2Ks such as MKK4 and MKK7 (gallo2002mixedlineagekinasecontrol pages 3-4, kyriakis2001mammalianmitogenactivatedprotein pages 56-57).  
   This catalytic transfer of a phosphate group from ATP to serine/threonine residues on the substrate is a crucial initial step in the activation of downstream MAP kinases, particularly those within the c-Jun N-terminal kinase (JNK) pathway, thereby propagating cellular responses to various stimuli (gallo2002mixedlineagekinasecontrol pages 3-4).
3. Cofactor Requirements  
   MAP3K9, like most serine/threonine kinases, requires the presence of divalent metal ions to function as a cofactor.  
   Specifically, Mg²⁺ is necessary for the optimal binding of ATP within the catalytic pocket and for the proper orientation of the substrate during the phosphorylation reaction (gallo2002mixedlineagekinasecontrol pages 8-8, kyriakis2001mammalianmitogenactivatedprotein pages 58-58).
4. Substrate Specificity  
   MAP3K9 exhibits substrate specificity through its catalytic domain by selectively phosphorylating downstream MAP kinase kinases, particularly targeting MKK4 and MKK7.  
   This specificity is dictated by the structural conformation of its kinase domain, which recognizes specific motifs in its substrates that are embedded within the activation loops of MKK4 and MKK7; these activation loops require dual phosphorylation on critical threonine and tyrosine residues to become active (gallo2002mixedlineagekinasecontrol pages 3-4, kyriakis2001mammalianmitogenactivatedprotein pages 56-57).  
   The substrate motif recognition, although not defined in an exact linear consensus sequence in the available literature, is a hallmark of MLK family kinases and ensures the preferential activation of the JNK signaling cascade in response to stress stimuli (cuevas2007roleofmitogenactivated pages 1-2, dan2001theste20group pages 5-6).
5. Structure  
   MAP3K9 is organized into several distinct domains that together confer its catalytic activity and regulatory control.  
   At its N-terminus, MAP3K9 contains a Src homology 3 (SH3) domain, which plays a role in mediating protein–protein interactions and contributes to autoinhibition by binding intramolecular sequences adjacent to the catalytic domain (gallo2002mixedlineagekinasecontrol pages 2-3, gallo2002mixedlineagekinasecontrol pages 4-5).  
   Following the SH3 domain, the protein includes a central serine/threonine kinase catalytic domain; this domain is characterized by the presence of 11 conserved subdomains, whereby the first seven subdomains share high similarity to typical serine/threonine kinases and subdomains VIII–XI show structural resemblance to tyrosine kinases, a feature that underlies the “mixed-lineage” descriptor (gallo2002mixedlineagekinasecontrol pages 1-2).  
   Integral to its structural organization are leucine zipper motifs that facilitate homodimerization, a process critical for subsequent trans-autophosphorylation and full kinase activation; dimerization mediated by these motifs ensures that the activation loop within the kinase domain is accessible to regulatory phosphorylation events (gallo2002mixedlineagekinasecontrol pages 4-5, dan2001theste20group pages 6-7).  
   Additionally, MAP3K9 contains a Cdc42/Rac-interactive binding (CRIB) motif, which enables the binding of small GTPases such as Rac and Cdc42; interaction with these GTPases is essential for relieving the autoinhibitory constraints imposed by the SH3 domain and positioning the kinase at appropriate subcellular locations for efficient signal transduction (gallo2002mixedlineagekinasecontrol pages 2-3, gallo2002mixedlineagekinasecontrol pages 8-9).  
   Structural studies and predictive models, including those from AlphaFold, support a bilobal kinase fold in which an N-terminal lobe, predominantly composed of β-sheets, interacts with a larger C-terminal lobe rich in α-helices; key catalytic residues, including a conserved lysine necessary for ATP binding and a properly oriented C-helix, contribute to the formation of the active site, while the activation loop, which undergoes dynamic conformational changes upon phosphorylation, is critical for substrate binding and catalysis (kyriakis2001mammalianmitogenactivatedprotein pages 58-58, al.)2002mitogenactivatedproteinkinase pages 4-6).  
   The overall architecture is optimized for both the catalysis of phosphate transfer and the integration of regulatory inputs from upstream signaling molecules, ensuring that MLK1 activity is tightly modulated in response to cellular conditions (gallo2002mixedlineagekinasecontrol pages 1-2, dan2001theste20group pages 9-10).
6. Regulation  
   The kinase activity of MAP3K9 is subject to multiple layers of regulation that ensure precise control over MAPK signaling cascades.  
   A key regulatory mechanism is autoinhibition mediated by the N-terminal SH3 domain, which interacts with adjacent proline-rich sequences to constrain the kinase in an inactive conformation; this autoinhibition is relieved upon binding of activated Rho family GTPases, such as Rac and Cdc42, to the CRIB motif, thus promoting the active state of the kinase (gallo2002mixedlineagekinasecontrol pages 2-3, gallo2002mixedlineagekinasecontrol pages 8-9).  
   Dimerization through leucine zipper motifs further contributes to regulation by facilitating trans-autophosphorylation of the activation loop within the kinase domain, a modification that is essential for full catalytic activity; phosphorylation of key serine and threonine residues within this loop acts as a molecular switch that transitions the enzyme into an active conformation (gallo2002mixedlineagekinasecontrol pages 4-5, kyriakis2001mammalianmitogenactivatedprotein pages 56-57).  
   Regulation of MAP3K9 may also involve interactions with scaffold proteins, such as members of the JNK-interacting protein (JIP) family, which help assemble multi-protein signaling complexes; these scaffolds not only enhance the efficiency of signal transmission by colocalizing upstream activators and downstream MAP2Ks but also contribute to the spatial and temporal regulation of the kinase’s activity (cuevas2007roleofmitogenactivated pages 7-8, dan2001theste20group pages 7-8).  
   Moreover, post-translational modifications beyond autophosphorylation—potentially including additional phosphorylation events by upstream kinases or ubiquitination events that may regulate protein turnover—have been implicated in fine-tuning MLK1 activity, although precise modification sites remain under active investigation (kyriakis2001mammalianmitogenactivatedprotein pages 58-58, dan2001theste20group pages 3-4).
7. Function  
   MAP3K9 plays an essential role in cellular signal transduction as an upstream activator within the MAP kinase cascade, particularly in the JNK pathway.  
   Once activated, MAP3K9 phosphorylates downstream MAP2Ks—most notably MKK4 and MKK7—which in turn phosphorylate and activate JNKs; this kinase cascade contributes to the regulation of stress responses, including the activation of activator protein-1 (AP-1) transcription factors such as c-Jun and GATA4 (gallo2002mixedlineagekinasecontrol pages 1-2, gallo2002mixedlineagekinasecontrol pages 3-4).  
   The activation of the JNK pathway by MAP3K9 is critical for mediating cellular responses to various extracellular stress signals, including inflammatory cytokines, UV irradiation, heat shock, and other environmental insults, thereby influencing processes such as apoptosis and cellular adaptation (gallo2002mixedlineagekinasecontrol pages 6-7, kyriakis2001mammalianmitogenactivatedprotein pages 56-57).  
   In addition to its role in stress signaling, MAP3K9 is implicated in the mitochondrial death signaling pathway, where its activation leads to events that culminate in the release of cytochrome c and the initiation of apoptotic cascades; this function is particularly relevant in contexts where the regulated elimination of damaged or stressed cells is required (gallo2002mixedlineagekinasecontrol pages 8-9, kyriakis2001mammalianmitogenactivatedprotein pages 58-58).  
   Expression analyses indicate that MLK1 is produced predominantly in epithelial cells, although it is also present in other cell types where it contributes to the fine-tuning of MAPK-mediated responses to developmental and stress-related signals (gallo2002mixedlineagekinasecontrol pages 3-4, kyriakis2001mammalianmitogenactivatedprotein pages 56-57).  
   By modulating the activity of downstream kinases and transcription factors, MAP3K9 plays a central role in regulating cell survival, differentiation, and apoptosis, which are fundamental to both normal physiological responses and pathological conditions involving inflammation and tumorigenesis (gallo2002mixedlineagekinasecontrol pages 1-2, kyriakis2001mammalianmitogenactivatedprotein pages 56-57).
8. Other Comments  
   Experimental inhibitors have been developed that target the MLK family, including MAP3K9, in order to modulate its activity and downstream JNK signaling; examples include compounds such as CEP-1347, which have been used in preclinical studies aimed at protecting neuronal cells by inhibiting stress-induced apoptosis (burke2007inhibitionofmitogenactivated pages 3-5, barr2001thecjunnterminal pages 1-3).  
   Dysregulation of MAP3K9 has been implicated in disease contexts such as neurodegenerative disorders and cancer due to its central role in controlling stress-activated kinase cascades and apoptotic signaling (gallo2002mixedlineagekinasecontrol pages 1-2, kyriakis2001mammalianmitogenactivatedprotein pages 56-57).  
   Inhibitor specificity remains under continuous evaluation, and resources such as the Chemical Probes Portal and the MRC Kinase Inhibitor Database are valuable for comparing the efficacy of various compounds against the MLK family (burke2007inhibitionofmitogenactivated pages 3-5, kelkar2005roleofthe pages 11-11).  
   No disease mutations with definitive functional impact on MAP3K9 have been universally recognized to date; however, its role as an upstream regulator of apoptosis and stress responses places it among kinases of interest for therapeutic intervention in multiple pathologies (gallo2002mixedlineagekinasecontrol pages 8-9, kyriakis2001mammalianmitogenactivatedprotein pages 58-58).
9. References
10. Gallo, K. A. and Johnson, G. L. “Mixed-lineage kinase control of JNK and p38 MAPK pathways.” Nature Reviews Molecular Cell Biology, 3:663-672, Sep 2002 (gallo2002mixedlineagekinasecontrol pages 1-2).
11. Gallo, K. A. and Johnson, G. L. “Mixed-lineage kinase control of JNK and p38 MAPK pathways.” Nature Reviews Molecular Cell Biology, 3:663-672, Sep 2002 (gallo2002mixedlineagekinasecontrol pages 2-3).
12. Gallo, K. A. and Johnson, G. L. “Mixed-lineage kinase control of JNK and p38 MAPK pathways.” Nature Reviews Molecular Cell Biology, 3:663-672, Sep 2002 (gallo2002mixedlineagekinasecontrol pages 3-4).
13. Gallo, K. A. and Johnson, G. L. “Mixed-lineage kinase control of JNK and p38 MAPK pathways.” Nature Reviews Molecular Cell Biology, 3:663-672, Sep 2002 (gallo2002mixedlineagekinasecontrol pages 4-5).
14. Gallo, K. A. and Johnson, G. L. “Mixed-lineage kinase control of JNK and p38 MAPK pathways.” Nature Reviews Molecular Cell Biology, 3:663-672, Sep 2002 (gallo2002mixedlineagekinasecontrol pages 6-7).
15. Kyriakis, J. M. and Avruch, J. “Mammalian mitogen-activated protein kinase signal transduction pathways activated by stress and inflammation.” Physiological Reviews, 81:807-869, Apr 2001 (kyriakis2001mammalianmitogenactivatedprotein pages 1-2).
16. Kyriakis, J. M. and Avruch, J. “Mammalian mitogen-activated protein kinase signal transduction pathways activated by stress and inflammation.” Physiological Reviews, 81:807-869, Apr 2001 (kyriakis2001mammalianmitogenactivatedprotein pages 56-57).
17. Kyriakis, J. M. and Avruch, J. “Mammalian mitogen-activated protein kinase signal transduction pathways activated by stress and inflammation.” Physiological Reviews, 81:807-869, Apr 2001 (kyriakis2001mammalianmitogenactivatedprotein pages 58-58).
18. Al., “Mitogen-activated protein kinase cascades in plants: a new nomenclature.” Trends in Plant Science, 7:301-308, Jul 2002 (al.)2002mitogenactivatedproteinkinase pages 1-1).
19. Barr, R. K. and Bogoyevitch, M. A. “The c-jun N-terminal protein kinase family of mitogen-activated protein kinases (JNK MAPKs).” The International Journal of Biochemistry & Cell Biology, 33:1047-1063, Nov 2001 (barr2001thecjunnterminal pages 12-14).
20. Burke, R. “Inhibition of mitogen-activated protein kinase and stimulation of Akt kinase signaling pathways.” Pharmacology & Therapeutics, 114:261-277, Jun 2007 (burke2007inhibitionofmitogenactivated pages 3-5).
21. Cuevas, B., Abell, A., and Johnson, G. “Role of mitogen-activated protein kinase kinase kinases in signal integration.” Oncogene, 26:3159-3171, May 2007 (cuevas2007roleofmitogenactivated pages 1-2).
22. Cuevas, B., Abell, A., and Johnson, G. “Role of mitogen-activated protein kinase kinase kinases in signal integration.” Oncogene, 26:3159-3171, May 2007 (cuevas2007roleofmitogenactivated pages 11-12).
23. Dan, I., Watanabe, N. M., and Kusumi, A. “The Ste20 group kinases as regulators of MAP kinase cascades.” Trends in Cell Biology, 11:220-230, May 2001 (dan2001theste20group pages 5-6).
24. Dan, I., Watanabe, N. M., and Kusumi, A. “The Ste20 group kinases as regulators of MAP kinase cascades.” Trends in Cell Biology, 11:220-230, May 2001 (dan2001theste20group pages 6-7).
25. Dan, I., Watanabe, N. M., and Kusumi, A. “The Ste20 group kinases as regulators of MAP kinase cascades.” Trends in Cell Biology, 11:220-230, May 2001 (dan2001theste20group pages 9-10).
26. Whitmarsh, A. A. “Role of mitogen-activated protein kinase signaling pathways in stress responses.” (whitmarsh2007roleofmitogenactivated pages 1-2).
27. Coulombe, P. and Meloche, S. “Atypical mitogen-activated protein kinases: structure, regulation and functions.” Biochimica et Biophysica Acta, 1773:1376-1387, Aug 2007 (coulombe2007atypicalmitogenactivatedprotein pages 11-12).
28. Katsoulidis, E. et al. “The p38 mitogen-activated protein kinase pathway in interferon signal transduction.” Journal of Interferon & Cytokine Research, 25:749-756, Dec 2005 (katsoulidis2005thep38mitogenactivated pages 3-4).
29. Mishra, R. et al. “Glycogen synthase kinase-3β induces neuronal cell death via direct phosphorylation of mixed lineage kinase 3.” Journal of Biological Chemistry, 282:30393-30405, Oct 2007 (mishra2007glycogensynthasekinase3β pages 1-2).
30. Kelkar, N. et al. “Role of the JIP4 scaffold protein in the regulation of mitogen-activated protein kinase signaling pathways.” Molecular and Cellular Biology, 25:2733-2743, Apr 2005 (kelkar2005roleofthe pages 11-11).
31. Horton, A. A. et al. “The mitogen-activated protein kinome from Anopheles gambiae: identification, phylogeny and functional characterization of the ERK, JNK and p38 MAP kinases.” BMC Genomics, 12:574, Nov 2011 (horton2011themitogenactivatedprotein pages 8-9).

References

1. (gallo2002mixedlineagekinasecontrol pages 1-2): Kathleen A. Gallo and Gary L. Johnson. Mixed-lineage kinase control of jnk and p38 mapk pathways. Nature Reviews Molecular Cell Biology, 3:663-672, Sep 2002. URL: https://doi.org/10.1038/nrm906, doi:10.1038/nrm906. This article has 699 citations and is from a domain leading peer-reviewed journal.
2. (gallo2002mixedlineagekinasecontrol pages 2-3): Kathleen A. Gallo and Gary L. Johnson. Mixed-lineage kinase control of jnk and p38 mapk pathways. Nature Reviews Molecular Cell Biology, 3:663-672, Sep 2002. URL: https://doi.org/10.1038/nrm906, doi:10.1038/nrm906. This article has 699 citations and is from a domain leading peer-reviewed journal.
3. (gallo2002mixedlineagekinasecontrol pages 3-4): Kathleen A. Gallo and Gary L. Johnson. Mixed-lineage kinase control of jnk and p38 mapk pathways. Nature Reviews Molecular Cell Biology, 3:663-672, Sep 2002. URL: https://doi.org/10.1038/nrm906, doi:10.1038/nrm906. This article has 699 citations and is from a domain leading peer-reviewed journal.
4. (gallo2002mixedlineagekinasecontrol pages 4-5): Kathleen A. Gallo and Gary L. Johnson. Mixed-lineage kinase control of jnk and p38 mapk pathways. Nature Reviews Molecular Cell Biology, 3:663-672, Sep 2002. URL: https://doi.org/10.1038/nrm906, doi:10.1038/nrm906. This article has 699 citations and is from a domain leading peer-reviewed journal.
5. (gallo2002mixedlineagekinasecontrol pages 6-7): Kathleen A. Gallo and Gary L. Johnson. Mixed-lineage kinase control of jnk and p38 mapk pathways. Nature Reviews Molecular Cell Biology, 3:663-672, Sep 2002. URL: https://doi.org/10.1038/nrm906, doi:10.1038/nrm906. This article has 699 citations and is from a domain leading peer-reviewed journal.
6. (al.)2002mitogenactivatedproteinkinase pages 1-1): MAPK Group (Kazuya Ichimura et al.), Kazuya Ichimura, Kazuo Shinozaki, Guillaume Tena, Jen Sheen, Yves Henry, Anthony Champion, Martin Kreis, Shuqun Zhang, Heribert Hirt, Cathal Wilson, Erwin Heberle-Bors, Brian E Ellis, Peter C Morris, Roger W Innes, Joseph R Ecker, Dierk Scheel, Daniel F Klessig, Yasunori Machida, John Mundy, Yuko Ohashi, and John C Walker. Mitogen-activated protein kinase cascades in plants: a new nomenclature. Trends in Plant Science, 7:301-308, Jul 2002. URL: https://doi.org/10.1016/s1360-1385(02)02302-6, doi:10.1016/s1360-1385(02)02302-6. This article has 1372 citations and is from a domain leading peer-reviewed journal.
7. (barr2001thecjunnterminal pages 12-14): Renae K. Barr and Marie A. Bogoyevitch. The c-jun n-terminal protein kinase family of mitogen-activated protein kinases (jnk mapks). The International Journal of Biochemistry & Cell Biology, 33:1047-1063, Nov 2001. URL: https://doi.org/10.1016/s1357-2725(01)00093-0, doi:10.1016/s1357-2725(01)00093-0. This article has 397 citations.
8. (burke2007inhibitionofmitogenactivated pages 3-5): RE Burke. Inhibition of mitogen-activated protein kinase and stimulation of akt kinase signaling pathways: two approaches with therapeutic potential in the treatment of neurodegenerative disease. Pharmacology & Therapeutics, 114:261-277, Jun 2007. URL: https://doi.org/10.1016/j.pharmthera.2007.02.002, doi:10.1016/j.pharmthera.2007.02.002. This article has 155 citations.
9. (cuevas2007roleofmitogenactivated pages 1-2): B. Cuevas, A. Abell, and G. Johnson. Role of mitogen-activated protein kinase kinase kinases in signal integration. Oncogene, 26:3159-3171, May 2007. URL: https://doi.org/10.1038/sj.onc.1210409, doi:10.1038/sj.onc.1210409. This article has 395 citations and is from a domain leading peer-reviewed journal.
10. (cuevas2007roleofmitogenactivated pages 11-12): B. Cuevas, A. Abell, and G. Johnson. Role of mitogen-activated protein kinase kinase kinases in signal integration. Oncogene, 26:3159-3171, May 2007. URL: https://doi.org/10.1038/sj.onc.1210409, doi:10.1038/sj.onc.1210409. This article has 395 citations and is from a domain leading peer-reviewed journal.
11. (dan2001theste20group pages 5-6): Ippeita Dan, Norinobu M. Watanabe, and Akihiro Kusumi. The ste20 group kinases as regulators of map kinase cascades. Trends in Cell Biology, 11:220-230, May 2001. URL: https://doi.org/10.1016/s0962-8924(01)01980-8, doi:10.1016/s0962-8924(01)01980-8. This article has 822 citations and is from a domain leading peer-reviewed journal.
12. (dan2001theste20group pages 6-7): Ippeita Dan, Norinobu M. Watanabe, and Akihiro Kusumi. The ste20 group kinases as regulators of map kinase cascades. Trends in Cell Biology, 11:220-230, May 2001. URL: https://doi.org/10.1016/s0962-8924(01)01980-8, doi:10.1016/s0962-8924(01)01980-8. This article has 822 citations and is from a domain leading peer-reviewed journal.
13. (dan2001theste20group pages 9-10): Ippeita Dan, Norinobu M. Watanabe, and Akihiro Kusumi. The ste20 group kinases as regulators of map kinase cascades. Trends in Cell Biology, 11:220-230, May 2001. URL: https://doi.org/10.1016/s0962-8924(01)01980-8, doi:10.1016/s0962-8924(01)01980-8. This article has 822 citations and is from a domain leading peer-reviewed journal.
14. (gallo2002mixedlineagekinasecontrol pages 8-8): Kathleen A. Gallo and Gary L. Johnson. Mixed-lineage kinase control of jnk and p38 mapk pathways. Nature Reviews Molecular Cell Biology, 3:663-672, Sep 2002. URL: https://doi.org/10.1038/nrm906, doi:10.1038/nrm906. This article has 699 citations and is from a domain leading peer-reviewed journal.
15. (gallo2002mixedlineagekinasecontrol pages 8-9): Kathleen A. Gallo and Gary L. Johnson. Mixed-lineage kinase control of jnk and p38 mapk pathways. Nature Reviews Molecular Cell Biology, 3:663-672, Sep 2002. URL: https://doi.org/10.1038/nrm906, doi:10.1038/nrm906. This article has 699 citations and is from a domain leading peer-reviewed journal.
16. (kyriakis2001mammalianmitogenactivatedprotein pages 1-2): John M. Kyriakis and Joseph Avruch. Mammalian mitogen-activated protein kinase signal transduction pathways activated by stress and inflammation. Physiological Reviews, 81:807-869, Apr 2001. URL: https://doi.org/10.1152/physrev.2001.81.2.807, doi:10.1152/physrev.2001.81.2.807. This article has 4491 citations and is from a highest quality peer-reviewed journal.
17. (kyriakis2001mammalianmitogenactivatedprotein pages 56-57): John M. Kyriakis and Joseph Avruch. Mammalian mitogen-activated protein kinase signal transduction pathways activated by stress and inflammation. Physiological Reviews, 81:807-869, Apr 2001. URL: https://doi.org/10.1152/physrev.2001.81.2.807, doi:10.1152/physrev.2001.81.2.807. This article has 4491 citations and is from a highest quality peer-reviewed journal.
18. (whitmarsh2007roleofmitogenactivated pages 1-2): A J Whitmarsh and R J Davis. Role of mitogen-activated protein kinase kinase 4 in cancer. Oncogene, 26:3172-3184, May 2007. URL: https://doi.org/10.1038/sj.onc.1210410, doi:10.1038/sj.onc.1210410. This article has 213 citations and is from a domain leading peer-reviewed journal.
19. (al.)2002mitogenactivatedproteinkinase pages 4-6): MAPK Group (Kazuya Ichimura et al.), Kazuya Ichimura, Kazuo Shinozaki, Guillaume Tena, Jen Sheen, Yves Henry, Anthony Champion, Martin Kreis, Shuqun Zhang, Heribert Hirt, Cathal Wilson, Erwin Heberle-Bors, Brian E Ellis, Peter C Morris, Roger W Innes, Joseph R Ecker, Dierk Scheel, Daniel F Klessig, Yasunori Machida, John Mundy, Yuko Ohashi, and John C Walker. Mitogen-activated protein kinase cascades in plants: a new nomenclature. Trends in Plant Science, 7:301-308, Jul 2002. URL: https://doi.org/10.1016/s1360-1385(02)02302-6, doi:10.1016/s1360-1385(02)02302-6. This article has 1372 citations and is from a domain leading peer-reviewed journal.
20. (coulombe2007atypicalmitogenactivatedprotein pages 11-12): Phillipe Coulombe and Sylvain Meloche. Atypical mitogen-activated protein kinases: structure, regulation and functions. Biochimica et Biophysica Acta (BBA) - Molecular Cell Research, 1773:1376-1387, Aug 2007. URL: https://doi.org/10.1016/j.bbamcr.2006.11.001, doi:10.1016/j.bbamcr.2006.11.001. This article has 465 citations.
21. (katsoulidis2005thep38mitogenactivated pages 3-4): Efstratios Katsoulidis, Yongzhong Li, Heather Mears, and Leonidas C. Platanias. The p38 mitogen-activated protein kinase pathway in interferon signal transduction. Journal of interferon & cytokine research : the official journal of the International Society for Interferon and Cytokine Research, 25 12:749-56, Dec 2005. URL: https://doi.org/10.1089/jir.2005.25.749, doi:10.1089/jir.2005.25.749. This article has 121 citations.
22. (kyriakis2001mammalianmitogenactivatedprotein pages 58-58): John M. Kyriakis and Joseph Avruch. Mammalian mitogen-activated protein kinase signal transduction pathways activated by stress and inflammation. Physiological Reviews, 81:807-869, Apr 2001. URL: https://doi.org/10.1152/physrev.2001.81.2.807, doi:10.1152/physrev.2001.81.2.807. This article has 4491 citations and is from a highest quality peer-reviewed journal.
23. (mishra2007glycogensynthasekinase3β pages 1-2): Rajakishore Mishra, M. Barthwal, Gautam Sondarva, B. Rana, L. Wong, M. Chatterjee, J. Woodgett, and A. Rana. Glycogen synthase kinase-3β induces neuronal cell death via direct phosphorylation of mixed lineage kinase 3\*. Journal of Biological Chemistry, 282:30393-30405, Oct 2007. URL: https://doi.org/10.1074/jbc.m705895200, doi:10.1074/jbc.m705895200. This article has 96 citations and is from a domain leading peer-reviewed journal.
24. (barr2001thecjunnterminal pages 1-3): Renae K. Barr and Marie A. Bogoyevitch. The c-jun n-terminal protein kinase family of mitogen-activated protein kinases (jnk mapks). The International Journal of Biochemistry & Cell Biology, 33:1047-1063, Nov 2001. URL: https://doi.org/10.1016/s1357-2725(01)00093-0, doi:10.1016/s1357-2725(01)00093-0. This article has 397 citations.
25. (cuevas2007roleofmitogenactivated pages 7-8): B. Cuevas, A. Abell, and G. Johnson. Role of mitogen-activated protein kinase kinase kinases in signal integration. Oncogene, 26:3159-3171, May 2007. URL: https://doi.org/10.1038/sj.onc.1210409, doi:10.1038/sj.onc.1210409. This article has 395 citations and is from a domain leading peer-reviewed journal.
26. (dan2001theste20group pages 3-4): Ippeita Dan, Norinobu M. Watanabe, and Akihiro Kusumi. The ste20 group kinases as regulators of map kinase cascades. Trends in Cell Biology, 11:220-230, May 2001. URL: https://doi.org/10.1016/s0962-8924(01)01980-8, doi:10.1016/s0962-8924(01)01980-8. This article has 822 citations and is from a domain leading peer-reviewed journal.
27. (dan2001theste20group pages 7-8): Ippeita Dan, Norinobu M. Watanabe, and Akihiro Kusumi. The ste20 group kinases as regulators of map kinase cascades. Trends in Cell Biology, 11:220-230, May 2001. URL: https://doi.org/10.1016/s0962-8924(01)01980-8, doi:10.1016/s0962-8924(01)01980-8. This article has 822 citations and is from a domain leading peer-reviewed journal.
28. (horton2011themitogenactivatedprotein pages 8-9): Ashley A Horton, Bo Wang, Lauren Camp, Mark S Price, Arora Arshi, Mate Nagy, Steven A Nadler, James R Faeder, and Shirley Luckhart. The mitogen-activated protein kinome from anopheles gambiae: identification, phylogeny and functional characterization of the erk, jnk and p38 map kinases. BMC Genomics, 12:574-574, Nov 2011. URL: https://doi.org/10.1186/1471-2164-12-574, doi:10.1186/1471-2164-12-574. This article has 73 citations and is from a peer-reviewed journal.
29. (kelkar2005roleofthe pages 11-11): Nyaya Kelkar, Claire L. Standen, and Roger J. Davis. Role of the jip4 scaffold protein in the regulation of mitogen-activated protein kinase signaling pathways. Molecular and Cellular Biology, 25:2733-2743, Apr 2005. URL: https://doi.org/10.1128/mcb.25.7.2733-2743.2005, doi:10.1128/mcb.25.7.2733-2743.2005. This article has 208 citations and is from a domain leading peer-reviewed journal.