**1. Phylogeny**  
Mitogen‐activated protein kinase 13 (MAPK13), also known as p38 delta or SAPK4, belongs to the p38 MAPK subfamily, which comprises four isoforms: p38α (MAPK14), p38β (MAPK11), p38γ (MAPK12), and p38δ (MAPK13) (cerezoguisado2011mapk13(mitogenactivatedprotein pages 1-2). Phylogenetically, the p38 MAPKs are a distinct branch within the kinome that evolved in early eukaryotes and are conserved across mammalian species (arbabi2002mitogenactivatedproteinkinases pages 1-2). MAPK13 is thought to share approximately 60% overall amino acid identity with the more widely studied p38α and p38β isoforms while being more divergent from the p38γ isoform (cerezoguisado2011mapk13(mitogenactivatedprotein pages 1-2, bachstetter2010thep38map pages 1-3). Evolutionary analyses based on the protein kinase complement indicate that MAPK13 and its p38 relatives form a conserved set of signaling kinases that trace back to a common eukaryotic ancestor, thus representing a core component of cellular stress response mechanisms (kyriakis2001mammalianmitogenactivatedprotein pages 1-2, pearson2001mitogenactivatedprotein(map) pages 1-2). The conservation of the central kinase domain, including the activation loop motif, underscores their functional significance in stress-activated signaling cascades.

**2. Reaction Catalyzed**  
MAPK13 catalyzes the phosphorylation of serine/threonine residues in protein substrates during the transfer of a phosphate group from ATP. The chemical reaction can be summarized as follows: ATP + [protein]-(L-serine or L-threonine) → ADP + [protein]-(L-serine/threonine)-phosphate + H⁺ (johnson2002mitogenactivatedproteinkinase pages 1-2). This phosphorylation reaction is essential for modulating the activity, subcellular localization, and protein–protein interactions of many downstream targets.

**3. Cofactor Requirements**  
The catalytic activity of MAPK13 requires divalent metal ions, with Mg²⁺ serving as the primary cofactor. Mg²⁺ facilitates the proper binding of ATP in the kinase’s active site and is essential for the phosphate transfer reaction (zarubin2005activationandsignaling pages 5-6, roux2004erkandp38 pages 2-3).

**4. Substrate Specificity**  
MAPK13 phosphorylates serine/threonine residues on a broad range of substrates, and its substrate repertoire is estimated to include between 200 and 300 proteins. Among its substrates are transcription factors such as ELK1 and ATF2, which are directly activated upon phosphorylation, thereby modulating gene expression in response to pro-inflammatory cytokines and physical stress (cerezoguisado2011mapk13(mitogenactivatedprotein pages 1-2, pages 2-3). In addition, MAPK13 phosphorylates downstream kinases such as MAPKAPK2, which further propagate stress-signaling cascades (cerezoguisado2011mapk13(mitogenactivatedprotein pages 2-3). Other well-documented substrates include proteins involved in the regulation of protein translation, such as the eukaryotic elongation factor 2 kinase (EEF2K), as well as cytoskeletal regulatory proteins including MAPT (tau) and STMN1 (stathmin) (cerezoguisado2011mapk13(mitogenactivatedprotein pages 1-2, arbabi2002mitogenactivatedproteinkinases pages 4-4). Although a precise consensus phosphorylation motif for MAPK13 has not been exhaustively established in the literature provided, its substrate preference appears to align with motifs commonly recognized by p38 MAPK isoforms.

**5. Structure**  
MAPK13 is a serine/threonine kinase comprised of 365 amino acids with an approximate molecular weight of 40 kDa (cerezoguisado2011mapk13(mitogenactivatedprotein pages 1-2). Its central kinase domain adopts the canonical bilobal structure characteristic of the eukaryotic protein kinase superfamily, with a smaller N-terminal lobe that predominantly binds ATP and a larger C-terminal lobe that provides the substrate-binding site (tibbles1999thestressactivatedprotein pages 1-3). A key structural feature is the conserved activation loop containing the Thr-Gly-Tyr (TGY) motif; dual phosphorylation at Thr180 and Tyr182 within this motif is required for full activation of MAPK13 (cerezoguisado2011mapk13(mitogenactivatedprotein pages 1-2, zarubin2005activationandsignaling pages 3-5). The presence of this dual phosphorylation site permits conformational changes that align the catalytic residues for efficient phosphate transfer. Furthermore, the C-helix within the N-terminal lobe contributes to the formation of the hydrophobic spine that is critical for kinase activity, and additional docking domains facilitate interactions with upstream MAP kinase kinases (MKK3 and MKK6) as well as with specific substrates and regulatory proteins (roux2004erkandp38 pages 3-4, pearson2001mitogenactivatedprotein(map) pages 2-3). No unique structural domains beyond the conserved kinase core have been reported for MAPK13, but subtle variations in surface residues and the length of regions flanking the catalytic domain contribute to differences in substrate specificity and inhibitor sensitivity compared to other p38 isoforms (cerezoguisado2011mapk13(mitogenactivatedprotein pages 3-4, arbabi2002mitogenactivatedproteinkinases pages 4-4).

**6. Regulation**  
MAPK13 is activated primarily by dual phosphorylation of its activation loop TGY motif, a reaction catalyzed by the upstream kinases MKK3 and MKK6. In certain cell types, MKK3 appears to preferentially activate MAPK13, while in other contexts MKK6 is the predominant activator (cerezoguisado2011mapk13(mitogenactivatedprotein pages 1-2, zarubin2005activationandsignaling pages 2-3). This phosphorylation event induces a conformational change necessary for ATP binding and substrate access to the catalytic cleft. In addition, regulatory protein–protein interactions and possible feedback inhibition by downstream MAPK-activated protein kinases such as MAPKAPK2 modulate MAPK13 activity (cerezoguisado2011mapk13(mitogenactivatedprotein pages 2-3, dodeller2006thep38mitogenactivated pages 1-2). There is evidence that MAPK13 is differentially regulated compared to other p38 isoforms, partially due to differences in inhibitor sensitivity; for example, common pyridinyl imidazole inhibitors that effectively target p38α and p38β do not inhibit p38δ (MAPK13) efficiently, suggesting distinct regulatory conformations in the ATP-binding pocket (zarubin2005activationandsignaling pages 5-6, pearson2001mitogenactivatedprotein(map) pages 15-16). Dephosphorylation by protein phosphatases further contributes to its regulation, ensuring the transient nature of its activation following stress stimuli (kyriakis2001mammalianmitogenactivatedprotein pages 4-6).

**7. Function**  
MAPK13 plays a multifaceted role in cellular stress response and signal transduction. It is widely expressed in various tissues such as the testes, pancreas, kidney, and small intestine and is localized in both the cytoplasm and the nucleus (cerezoguisado2011mapk13(mitogenactivatedprotein pages 1-2). Upon activation by environmental stresses or pro-inflammatory cytokines, MAPK13 phosphorylates a broad range of substrates, thereby modulating numerous physiological processes. These include:

• Transcriptional regulation: MAPK13 phosphorylates transcription factors such as ELK1 and ATF2, leading to the activation of genes that mediate inflammatory responses and cellular adaptation to stress (cerezoguisado2011mapk13(mitogenactivatedprotein pages 1-2, pages 3-4).

• Protein translation control: By phosphorylating and inactivating the eukaryotic elongation factor 2 kinase (EEF2K), MAPK13 indirectly regulates protein synthesis, thereby influencing cellular growth and metabolism (cerezoguisado2011mapk13(mitogenactivatedprotein pages 1-2).

• Cytoskeletal remodeling: MAPK13 phosphorylates cytoskeletal-associated proteins such as MAPT (tau) and STMN1 (stathmin), which are involved in microtubule dynamics and cytoskeleton reorganization. These actions contribute to changes in cell shape, motility, and potentially cellular differentiation (cerezoguisado2011mapk13(mitogenactivatedprotein pages 1-2, arbabi2002mitogenactivatedproteinkinases pages 4-4).

• Keratinocyte differentiation and skin tumor development: In keratinocytes, MAPK13 regulates differentiation processes and modulates apoptosis. It has been implicated in the up-regulation of genes such as CXCL14 following UV irradiation, as well as in the phosphorylation of MYB, which leads to its rapid degradation via a proteasome-dependent pathway. Collectively, these activities have been linked to skin tumorigenesis (cerezoguisado2011mapk13(mitogenactivatedprotein pages 2-3, bachstetter2010thep38map pages 4-6).

• Regulation of insulin secretion: In pancreatic beta cells, MAPK13 phosphorylates and down-regulates PRKD1 (protein kinase D1), which plays an important role in insulin exocytosis. This function is critical for maintaining proper beta-cell survival and metabolic homeostasis (cerezoguisado2011mapk13(mitogenactivatedprotein pages 2-3).)

These diverse roles establish MAPK13 as an essential component in the cellular responses elicited by various extracellular stimuli, contributing to processes that span inflammation, cytoskeletal reorganization, gene expression, and metabolic regulation (arbabi2002mitogenactivatedproteinkinases pages 1-2, zarubin2005activationandsignaling pages 3-5).

**8. Other Comments**  
MAPK13 exhibits a distinct inhibitor sensitivity profile among the p38 MAPK isoforms. Commonly used pyridinyl imidazole compounds, such as SB203580, which potently inhibit p38α and p38β, fail to effectively inhibit MAPK13, underscoring its unique structural and regulatory features (zarubin2005activationandsignaling pages 5-6, pearson2001mitogenactivatedprotein(map) pages 15-16). Such differences have important implications for drug discovery and selective modulation of p38 MAPK signaling pathways in disease contexts. Dysregulation of MAPK13 has been associated with a variety of pathophysiological conditions, including inflammatory diseases, certain skin pathologies like psoriasis and skin tumorigenesis, and metabolic disorders related to impaired insulin secretion (cerezoguisado2011mapk13(mitogenactivatedprotein pages 2-3, bachstetter2010thep38map pages 4-6). Additionally, alterations in MAPK13 signaling have been noted in cancer and neurodegenerative diseases, particularly through its effects on proteins such as tau (MAPT) and stathmin (STMN1) (cerezoguisado2011mapk13(mitogenactivatedprotein pages 2-3, dodeller2006thep38mitogenactivated pages 2-3). The understanding of these disease associations continues to evolve as further studies elucidate the isoform-specific roles and regulation of MAPK13 compared to its p38 MAPK counterparts.

**9. References**  
1. cerezoguisado2011mapk13(mitogenactivatedprotein pages 1-2)  
2. cerezoguisado2011mapk13(mitogenactivatedprotein pages 2-3)  
3. cerezoguisado2011mapk13(mitogenactivatedprotein pages 3-4)  
4. arbabi2002mitogenactivatedproteinkinases pages 1-2  
5. arbabi2002mitogenactivatedproteinkinases pages 4-4  
6. bachstetter2010thep38map pages 1-3  
7. bachstetter2010thep38map pages 4-6  
8. cargnello2011activationandfunction pages 1-1  
9. cargnello2011activationandfunction pages 4-5  
10. dodeller2006thep38mitogenactivated pages 1-2  
11. dodeller2006thep38mitogenactivated pages 2-3  
12. johnson2002mitogenactivatedproteinkinase pages 1-2  
13. kyriakis2001mammalianmitogenactivatedprotein pages 1-2  
14. pearson2001mitogenactivatedprotein(map) pages 1-2  
15. pearson2001mitogenactivatedprotein(map) pages 15-16  
16. pearson2001mitogenactivatedprotein(map) pages 24-24  
17. pearson2001mitogenactivatedprotein(map) pages 2-3  
18. roux2004erkandp38 pages 1-1  
19. roux2004erkandp38 pages 2-3  
20. roux2004erkandp38 pages 3-4  
21. tibbles1999thestressactivatedprotein pages 1-3  
22. zarubin2005activationandsignaling pages 1-2  
23. zarubin2005activationandsignaling pages 2-3  
24. zarubin2005activationandsignaling pages 3-5  
25. zarubin2005activationandsignaling pages 5-6  
26. dodeller2006thep38mitogenactivated pages 10-11  
27. kyriakis2001mammalianmitogenactivatedprotein pages 4-6  
28. kyriakis2001mammalianmitogenactivatedprotein pages 6-7  
29. kyriakis2001mammalianmitogenactivatedprotein pages 9-11  
30. marber2011thep38mitogenactivated pages 1-2  
31. marber2011thep38mitogenactivated pages 5-6  
32. opdenakker2012mitogenactivatedprotein(map) pages 4-5  
33. pearson2001mitogenactivatedprotein(map) pages 20-21  
34. roux2004erkandp38 pages 17-18  
35. roux2004erkandp38 pages 22-22  
36. roux2004erkandp38 pages 5-7

References

1. (cerezoguisado2011mapk13(mitogenactivatedprotein pages 1-2): MI Cerezo-Guisado and A Cuenda. Mapk13 (mitogen-activated protein kinase 13). Atlas of Genetics and Cytogenetics in Oncology and Haematology, Nov 2011. URL: https://doi.org/10.4267/2042/44858, doi:10.4267/2042/44858. This article has 1 citations and is from a peer-reviewed journal.
2. (cerezoguisado2011mapk13(mitogenactivatedprotein pages 2-3): MI Cerezo-Guisado and A Cuenda. Mapk13 (mitogen-activated protein kinase 13). Atlas of Genetics and Cytogenetics in Oncology and Haematology, Nov 2011. URL: https://doi.org/10.4267/2042/44858, doi:10.4267/2042/44858. This article has 1 citations and is from a peer-reviewed journal.
3. (cerezoguisado2011mapk13(mitogenactivatedprotein pages 3-4): MI Cerezo-Guisado and A Cuenda. Mapk13 (mitogen-activated protein kinase 13). Atlas of Genetics and Cytogenetics in Oncology and Haematology, Nov 2011. URL: https://doi.org/10.4267/2042/44858, doi:10.4267/2042/44858. This article has 1 citations and is from a peer-reviewed journal.
4. (arbabi2002mitogenactivatedproteinkinases pages 1-2): Saman Arbabi and Ronald V. Maier. Mitogen-activated protein kinases. Critical Care Medicine, 30:S74-S79, Jan 2002. URL: https://doi.org/10.1097/00003246-200201001-00010, doi:10.1097/00003246-200201001-00010. This article has 251 citations and is from a domain leading peer-reviewed journal.
5. (arbabi2002mitogenactivatedproteinkinases pages 4-4): Saman Arbabi and Ronald V. Maier. Mitogen-activated protein kinases. Critical Care Medicine, 30:S74-S79, Jan 2002. URL: https://doi.org/10.1097/00003246-200201001-00010, doi:10.1097/00003246-200201001-00010. This article has 251 citations and is from a domain leading peer-reviewed journal.
6. (bachstetter2010thep38map pages 1-3): AD Bachstetter. The p38 map kinase family as regulators of proinflammatory cytokine production in degenerative diseases of the cns. Unknown journal, 2010.
7. (bachstetter2010thep38map pages 4-6): AD Bachstetter. The p38 map kinase family as regulators of proinflammatory cytokine production in degenerative diseases of the cns. Unknown journal, 2010.
8. (cargnello2011activationandfunction pages 1-1): Marie Cargnello and Philippe P. Roux. Activation and function of the mapks and their substrates, the mapk-activated protein kinases. Microbiology and Molecular Biology Reviews, 75:50-83, Mar 2011. URL: https://doi.org/10.1128/mmbr.00031-10, doi:10.1128/mmbr.00031-10. This article has 3999 citations and is from a domain leading peer-reviewed journal.
9. (cargnello2011activationandfunction pages 4-5): Marie Cargnello and Philippe P. Roux. Activation and function of the mapks and their substrates, the mapk-activated protein kinases. Microbiology and Molecular Biology Reviews, 75:50-83, Mar 2011. URL: https://doi.org/10.1128/mmbr.00031-10, doi:10.1128/mmbr.00031-10. This article has 3999 citations and is from a domain leading peer-reviewed journal.
10. (dodeller2006thep38mitogenactivated pages 1-2): Francis Dodeller and Hendrik Schulze-Koops. The p38 mitogen-activated protein kinase signaling cascade in cd4 t cells. Arthritis Research & Therapy, 8:205-205, Feb 2006. URL: https://doi.org/10.1186/ar1905, doi:10.1186/ar1905. This article has 149 citations.
11. (dodeller2006thep38mitogenactivated pages 2-3): Francis Dodeller and Hendrik Schulze-Koops. The p38 mitogen-activated protein kinase signaling cascade in cd4 t cells. Arthritis Research & Therapy, 8:205-205, Feb 2006. URL: https://doi.org/10.1186/ar1905, doi:10.1186/ar1905. This article has 149 citations.
12. (johnson2002mitogenactivatedproteinkinase pages 1-2): Gary L. Johnson and Razvan Lapadat. Mitogen-activated protein kinase pathways mediated by erk, jnk, and p38 protein kinases. Science, 298:1911-1912, Dec 2002. URL: https://doi.org/10.1126/science.1072682, doi:10.1126/science.1072682. This article has 5762 citations and is from a highest quality peer-reviewed journal.
13. (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 4484 citations and is from a highest quality peer-reviewed journal.
14. (pearson2001mitogenactivatedprotein(map) pages 24-24): G. Pearson, Fred L Robinson, T. Gibson, Bing-e Xu, M. Karandikar, K. Berman, and M. Cobb. Mitogen-activated protein (map) kinase pathways: regulation and physiological functions. Endocrine Reviews, 22:153-183, Apr 2001. URL: https://doi.org/10.1210/er.22.2.153, doi:10.1210/er.22.2.153. This article has 5932 citations and is from a domain leading peer-reviewed journal.
15. (roux2004erkandp38 pages 2-3): Philippe P. Roux and John Blenis. Erk and p38 mapk-activated protein kinases: a family of protein kinases with diverse biological functions. Microbiology and Molecular Biology Reviews, 68:320-344, Jun 2004. URL: https://doi.org/10.1128/mmbr.68.2.320-344.2004, doi:10.1128/mmbr.68.2.320-344.2004. This article has 3350 citations and is from a domain leading peer-reviewed journal.
16. (roux2004erkandp38 pages 3-4): Philippe P. Roux and John Blenis. Erk and p38 mapk-activated protein kinases: a family of protein kinases with diverse biological functions. Microbiology and Molecular Biology Reviews, 68:320-344, Jun 2004. URL: https://doi.org/10.1128/mmbr.68.2.320-344.2004, doi:10.1128/mmbr.68.2.320-344.2004. This article has 3350 citations and is from a domain leading peer-reviewed journal.
17. (tibbles1999thestressactivatedprotein pages 1-3): L. A. Tibbles and J. R. Woodgett. The stress-activated protein kinase pathways. Cellular and Molecular Life Sciences CMLS, 55:1230-1254, Aug 1999. URL: https://doi.org/10.1007/s000180050369, doi:10.1007/s000180050369. This article has 860 citations.
18. (zarubin2005activationandsignaling pages 1-2): Tyler ZARUBIN and Jiahuai HAN. Activation and signaling of the p38 map kinase pathway. Cell Research, 15:11-18, Jan 2005. URL: https://doi.org/10.1038/sj.cr.7290257, doi:10.1038/sj.cr.7290257. This article has 2282 citations and is from a domain leading peer-reviewed journal.
19. (zarubin2005activationandsignaling pages 2-3): Tyler ZARUBIN and Jiahuai HAN. Activation and signaling of the p38 map kinase pathway. Cell Research, 15:11-18, Jan 2005. URL: https://doi.org/10.1038/sj.cr.7290257, doi:10.1038/sj.cr.7290257. This article has 2282 citations and is from a domain leading peer-reviewed journal.
20. (zarubin2005activationandsignaling pages 3-5): Tyler ZARUBIN and Jiahuai HAN. Activation and signaling of the p38 map kinase pathway. Cell Research, 15:11-18, Jan 2005. URL: https://doi.org/10.1038/sj.cr.7290257, doi:10.1038/sj.cr.7290257. This article has 2282 citations and is from a domain leading peer-reviewed journal.
21. (zarubin2005activationandsignaling pages 5-6): Tyler ZARUBIN and Jiahuai HAN. Activation and signaling of the p38 map kinase pathway. Cell Research, 15:11-18, Jan 2005. URL: https://doi.org/10.1038/sj.cr.7290257, doi:10.1038/sj.cr.7290257. This article has 2282 citations and is from a domain leading peer-reviewed journal.
22. (dodeller2006thep38mitogenactivated pages 10-11): Francis Dodeller and Hendrik Schulze-Koops. The p38 mitogen-activated protein kinase signaling cascade in cd4 t cells. Arthritis Research & Therapy, 8:205-205, Feb 2006. URL: https://doi.org/10.1186/ar1905, doi:10.1186/ar1905. This article has 149 citations.
23. (kyriakis2001mammalianmitogenactivatedprotein pages 4-6): 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 4484 citations and is from a highest quality peer-reviewed journal.
24. (kyriakis2001mammalianmitogenactivatedprotein pages 6-7): 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 4484 citations and is from a highest quality peer-reviewed journal.
25. (kyriakis2001mammalianmitogenactivatedprotein pages 9-11): 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 4484 citations and is from a highest quality peer-reviewed journal.
26. (marber2011thep38mitogenactivated pages 1-2): Michael S. Marber, Beth Rose, and Yibin Wang. The p38 mitogen-activated protein kinase pathway—a potential target for intervention in infarction, hypertrophy, and heart failure. Journal of Molecular and Cellular Cardiology, 51:485-490, Oct 2011. URL: https://doi.org/10.1016/j.yjmcc.2010.10.021, doi:10.1016/j.yjmcc.2010.10.021. This article has 189 citations and is from a domain leading peer-reviewed journal.
27. (marber2011thep38mitogenactivated pages 5-6): Michael S. Marber, Beth Rose, and Yibin Wang. The p38 mitogen-activated protein kinase pathway—a potential target for intervention in infarction, hypertrophy, and heart failure. Journal of Molecular and Cellular Cardiology, 51:485-490, Oct 2011. URL: https://doi.org/10.1016/j.yjmcc.2010.10.021, doi:10.1016/j.yjmcc.2010.10.021. This article has 189 citations and is from a domain leading peer-reviewed journal.
28. (opdenakker2012mitogenactivatedprotein(map) pages 4-5): Kelly Opdenakker, Tony Remans, Jaco Vangronsveld, and Ann Cuypers. Mitogen-activated protein (map) kinases in plant metal stress: regulation and responses in comparison to other biotic and abiotic stresses. International Journal of Molecular Sciences, 13:7828-7853, Jun 2012. URL: https://doi.org/10.3390/ijms13067828, doi:10.3390/ijms13067828. This article has 161 citations and is from a peer-reviewed journal.
29. (pearson2001mitogenactivatedprotein(map) pages 1-2): G. Pearson, Fred L Robinson, T. Gibson, Bing-e Xu, M. Karandikar, K. Berman, and M. Cobb. Mitogen-activated protein (map) kinase pathways: regulation and physiological functions. Endocrine Reviews, 22:153-183, Apr 2001. URL: https://doi.org/10.1210/er.22.2.153, doi:10.1210/er.22.2.153. This article has 5932 citations and is from a domain leading peer-reviewed journal.
30. (pearson2001mitogenactivatedprotein(map) pages 15-16): G. Pearson, Fred L Robinson, T. Gibson, Bing-e Xu, M. Karandikar, K. Berman, and M. Cobb. Mitogen-activated protein (map) kinase pathways: regulation and physiological functions. Endocrine Reviews, 22:153-183, Apr 2001. URL: https://doi.org/10.1210/er.22.2.153, doi:10.1210/er.22.2.153. This article has 5932 citations and is from a domain leading peer-reviewed journal.
31. (pearson2001mitogenactivatedprotein(map) pages 2-3): G. Pearson, Fred L Robinson, T. Gibson, Bing-e Xu, M. Karandikar, K. Berman, and M. Cobb. Mitogen-activated protein (map) kinase pathways: regulation and physiological functions. Endocrine Reviews, 22:153-183, Apr 2001. URL: https://doi.org/10.1210/er.22.2.153, doi:10.1210/er.22.2.153. This article has 5932 citations and is from a domain leading peer-reviewed journal.
32. (roux2004erkandp38 pages 1-1): Philippe P. Roux and John Blenis. Erk and p38 mapk-activated protein kinases: a family of protein kinases with diverse biological functions. Microbiology and Molecular Biology Reviews, 68:320-344, Jun 2004. URL: https://doi.org/10.1128/mmbr.68.2.320-344.2004, doi:10.1128/mmbr.68.2.320-344.2004. This article has 3350 citations and is from a domain leading peer-reviewed journal.
33. (pearson2001mitogenactivatedprotein(map) pages 20-21): G. Pearson, Fred L Robinson, T. Gibson, Bing-e Xu, M. Karandikar, K. Berman, and M. Cobb. Mitogen-activated protein (map) kinase pathways: regulation and physiological functions. Endocrine Reviews, 22:153-183, Apr 2001. URL: https://doi.org/10.1210/er.22.2.153, doi:10.1210/er.22.2.153. This article has 5932 citations and is from a domain leading peer-reviewed journal.
34. (roux2004erkandp38 pages 17-18): Philippe P. Roux and John Blenis. Erk and p38 mapk-activated protein kinases: a family of protein kinases with diverse biological functions. Microbiology and Molecular Biology Reviews, 68:320-344, Jun 2004. URL: https://doi.org/10.1128/mmbr.68.2.320-344.2004, doi:10.1128/mmbr.68.2.320-344.2004. This article has 3350 citations and is from a domain leading peer-reviewed journal.
35. (roux2004erkandp38 pages 22-22): Philippe P. Roux and John Blenis. Erk and p38 mapk-activated protein kinases: a family of protein kinases with diverse biological functions. Microbiology and Molecular Biology Reviews, 68:320-344, Jun 2004. URL: https://doi.org/10.1128/mmbr.68.2.320-344.2004, doi:10.1128/mmbr.68.2.320-344.2004. This article has 3350 citations and is from a domain leading peer-reviewed journal.
36. (roux2004erkandp38 pages 5-7): Philippe P. Roux and John Blenis. Erk and p38 mapk-activated protein kinases: a family of protein kinases with diverse biological functions. Microbiology and Molecular Biology Reviews, 68:320-344, Jun 2004. URL: https://doi.org/10.1128/mmbr.68.2.320-344.2004, doi:10.1128/mmbr.68.2.320-344.2004. This article has 3350 citations and is from a domain leading peer-reviewed journal.