metalloproteinase-1. *Molecular Medicine Reports*, *11*(5), 3344. https://doi.org/10.3892/MMR.2015.3212

Chen, S., He, Z., & Xu, J. (2020). Application of adipose-derived stem cells in photoaging: basic science and literature review. *Stem Cell Research & Therapy*, *11*(1). https://doi.org/10.1186/S13287-020-01994-Z

Chen, X., Yang, C., & Jiang, G. (2021). Research progress on skin photoaging and oxidative stress. *Advances in Dermatology and Allergology/Postępy Dermatologii i Alergologii*, *38*(6), 931. https://doi.org/10.5114/ADA.2021.112275

Cui, N., Hu, M., & Khalil, R. A. (2017). Biochemical and Biological Attributes of Matrix Metalloproteinases. *Progress in Molecular Biology and Translational Science*, *147*, 1. https://doi.org/10.1016/BS.PMBTS.2017.02.005

de Gonzalo-Calvo, D., Marchese, M., Hellemans, J., Betsou, F., Skov Frisk, N. L., Dalgaard, L. T., Lakkisto, P., Foy, C., Scherer, A., Garcia Bermejo, M. L., & Devaux, Y. (2022). Consensus guidelines for the validation of qRT-PCR assays in clinical research by the CardioRNA consortium. *Molecular Therapy. Methods & Clinical Development*, *24*, 171. https://doi.org/10.1016/j.omtm.2021.12.007

Dick, M. K., Miao, J. H., & Limaiem, F. (2023). Histology, Fibroblast. *StatPearls*. https://www.ncbi.nlm.nih.gov/books/NBK541065/

Fokkens, B. T., & Smit, A. J. (2016). Skin fluorescence as a clinical tool for non-invasive assessment of advanced glycation and long-term complications of diabetes. *Glycoconjugate Journal*, *33*(4), 527. https://doi.org/10.1007/S10719-016-9683-1

Giri Putra, L. A., Yonathan, C. J., Niedhatrata, N. I., Rizka Firdaus, M. H., & Yoewono, J. R. (2020). A review of the development of Polymerase Chain Reaction technique and its uses in Scientific field. *Stannum : Jurnal Sains Dan Terapan Kimia*, *2*(1), 14–30. https://doi.org/10.33019/JSTK.V2I1.1619

Goh, C. L., Kang, H. Y., Morita, A., Zhang, C., Wu, Y., Prakoeswa, C. R. S., Sau, N. H., Kerob, D., Flament, F., & Wei, L. (2024). Awareness of sun exposure risks and photoprotection for preventing pigmentary disorders in Asian populations: Survey results from three Asian countries and expert panel recommendations. *Photodermatology, Photoimmunology & Photomedicine*, *40*(1). https://doi.org/10.1111/phpp.12932

Gromkowska-Kępka, K. J., Puścion-Jakubik, A., Markiewicz-Żukowska, R., & Socha, K. (2021). The impact of ultraviolet radiation on skin photoaging — review of in vitro studies. *Journal of Cosmetic Dermatology*, *20*(11), 3427. https://doi.org/10.1111/JOCD.14033

Ham, S. A., Yoo, T., Hwang, J. S., Kang, E. S., Paek, K. S., Park, C., Kim, J. H., Do, J. T., & Seo, H. G. (2014). Peroxisome proliferator-activated receptor δ modulates MMP-2 secretion and elastin expression in human dermal fibroblasts exposed to ultraviolet B radiation. *Journal of Dermatological Science*, *76*(1), 44–50. https://doi.org/10.1016/J.JDERMSCI.2014.07.011

Hergesell, K., Paraskevopoulou, A., Opálka, L., Velebný, V., Vávrová, K., & Dolečková, I. (2023). The effect of long-term cigarette smoking on selected skin barrier proteins and lipids. *Scientific Reports*, *13*(1). https://doi.org/10.1038/S41598-023-38178-7

Kammeyer, A., & Luiten, R. M. (2015). Oxidation events and skin aging. *Ageing Research Reviews*, *21*, 16–29. https://doi.org/10.1016/J.ARR.2015.01.001

Kapoor, C., Vaidya, S., Wadhwan, V., Hitesh, Kaur, G., & Pathak, A. (2016). Seesaw of matrix metalloproteinases (MMPs). *Journal of Cancer Research and Therapeutics*, *12*(1), 28–35. https://doi.org/10.4103/0973-1482.157337

Kim, D. J., Iwasaki, A., Chien, A. L., & Kang, S. (2022). UVB-mediated DNA damage induces matrix metalloproteinases to promote photoaging in an AhR- and SP1-dependent manner. *JCI Insight*, *7*(9), e156344. https://doi.org/10.1172/JCI.INSIGHT.156344

Lee, J. S., Min, J. W., Gye, S. B., Kim, Y. W., Kang, H. C., Choi, Y. S., Seo, W. S., & Lee, B. Y. (2024). Suppression of UVB-Induced MMP-1 Expression in Human Skin Fibroblasts Using Lysate of Lactobacillus iners Derived from Korean Women's Skin in Their Twenties. *Current Issues in Molecular Biology*, *46*(1), 513. https://doi.org/10.3390/CIMB46010033

Lestari, W., Puspita, D. A., Mizfaruddin, M., & Hajar, S. (2023). The Effect of Sun Exposure on the Severity Degree of Photoaging and Skin Hydration on Service Workers at dr. Zainoel Abidin Regional General Hospital Banda Aceh. *Berkala Ilmu Kesehatan Kulit Dan Kelamin*, *35*(3), 214–218. https://doi.org/10.20473/bikk.V35.3.2023.214-218

Li, L., Ngo, H. T. T., Hwang, E., Wei, X., Liu, Y., Liu, J., & Yi, T. H. (2019). Conditioned Medium from Human Adipose-Derived Mesenchymal Stem Cell Culture Prevents UVB-Induced Skin Aging in Human Keratinocytes and Dermal

Fibroblasts. *International Journal of Molecular Sciences*, *21*(1), 49. https://doi.org/10.3390/ijms21010049

Liang, Y., Su, W., & Wang, F. (2023). Skin Ageing: A Progressive, Multi-Factorial Condition Demanding an Integrated, Multilayer-Targeted Remedy. *Clinical, Cosmetic and Investigational Dermatology*, *16*, 1215. https://doi.org/10.2147/CCID.S408765

Lipa, K., Zając, N., Owczarek, W., Ciechanowicz, P., Szymańska, E., & Walecka, I. (2021). Does smoking affect your skin? *Advances in Dermatology and Allergology/Postępy Dermatologii i Alergologii*, *38*(3), 371. https://doi.org/10.5114/ADA.2021.103000

Lorz, L. R., Yoo, B. C., Kim, M. Y., & Cho, J. Y. (2019). Anti-Wrinkling and Anti-Melanogenic Effect of Pradosia mutisii Methanol Extract. *International Journal of Molecular Sciences*, *20*(5), 1043. https://doi.org/10.3390/IJMS20051043

Marwinda, T. D. N., & Danardono, D. (2024). Perbandingan Iuran Normal Pensiun Metode Entry Age Normal dan Projected Unit Credit dengan Suku Bunga CIR (Cox Ingersoll Ross). *JURNAL PEMBELAJARAN DAN MATEMATIKA SIGMA (JPMS)*, *10*(2), 133–138. https://doi.org/10.36987/jpms.v10i2.5881

Mayangsari, E., Mustika, A., Nurdiana, N., & Samad, N. A. (2024). Comparison of UVA vs UVB Photoaging Rat Models in Short-term Exposure. *Medical Archives*, *78*(2), 88. https://doi.org/10.5455/medarh.2024.78.88-91

Moraes, V. R., Melo, M. O., & Maia Campos, P. M. B. G. (2023). Evaluation of Morphological and Structural Skin Alterations on Diabetic Subjects by

Biophysical and Imaging Techniques. *Life*, *13*(2). https://doi.org/10.3390/LIFE13020579

Murlistyarini, S., & Dani, A. A. (2023). THE ROLE OF MATRIX METALLOPROTEINASE (MMP) IN PHOTOAGING PROCESS. *Journal of Dermatology, Venereology and Aesthetic*, *3*(1), 13–21. https://jdva.ub.ac.id/index.php/jdva/article/view/24

Nugroho, A. A. (2023). Efek Sekretom Sel Punca Mesenkimal Asal Jaringan Adiposa Donor Usia Muda dan Tua Terhadap Sel Fibroblas Yang Diinduksi UVB [Thesis, Universitas Indonesia]. In P. Sari & K. Karina (Eds.), *Effect of Secretome of Mesenchymal Stem Cells from Adipose Tissue in Old and Young Donors on Fibroblast Cells Induced by UVB*. https://lib.ui.ac.id/detail?id=T23580fk

Park, J. E., Pyun, H. B., Woo, S. W., Jeong, J. H., & Hwang, J. K. (2014). The protective effect of Kaempferia parviflora extract on UVB-induced skin photoaging in hairless mice. *Photodermatology, Photoimmunology & Photomedicine*, *30*(5), 237–245. https://doi.org/10.1111/PHPP.12097

Parkinson, L. G., Toro, A., Zhao, H., Brown, K., Tebbutt, S. J., & Granville, D. J. (2015). Granzyme B mediates both direct and indirect cleavage of extracellular matrix in skin after chronic low-dose ultraviolet light irradiation. *Aging Cell*, *14*(1), 67. https://doi.org/10.1111/ACEL.12298

Pittayapruek, P., Meephansan, J., Prapapan, O., Komine, M., & Ohtsuki, M. (2016). Role of Matrix Metalloproteinases in Photoaging and Photocarcinogenesis. *International Journal of Molecular Sciences*, *17*(6). https://doi.org/10.3390/IJMS17060868

Plikus, M. V., Wang, X., Sinha, S., Forte, E., Thompson, S. M., Herzog, E. L., Driskell, R. R., Rosenthal, N., Biernaskie, J., & Horsley, V. (2021a). Fibroblasts: origins, definitions, and functions in health and disease. *Cell*, *184*(15), 3852. https://doi.org/10.1016/J.CELL.2021.06.024

Plikus, M. V., Wang, X., Sinha, S., Forte, E., Thompson, S. M., Herzog, E. L., Driskell, R. R., Rosenthal, N., Biernaskie, J., & Horsley, V. (2021b). Fibroblasts: origins, definitions, and functions in health and disease. *Cell*, *184*(15), 3852. https://doi.org/10.1016/J.CELL.2021.06.024

Prieux, R., Eeman, M., Rothen-Rutishauser, B., & Valacchi, G. (2020). Mimicking cigarette smoke exposure to assess cutaneous toxicity. *Toxicology in Vitro : An International Journal Published in Association with BIBRA*, *62*. https://doi.org/10.1016/J.TIV.2019.104664

Qian, H., Shan, Y., Gong, R., Lin, D., Zhang, M., Wang, C., & Wang, L. (2022). Mechanism of action and therapeutic effects of oxidative stress and stem cell-based materials in skin aging: Current evidence and future perspectives. *Frontiers in Bioengineering and Biotechnology*, *10*. https://doi.org/10.3389/FBIOE.2022.1082403

Quantitative PCR (qPCR) Data Analysis - CH. (n.d.). Retrieved April 17, 2025, from https://www.thermofisher.com/uk/en/home/life-science/pcr/real-time-pcr/real-time-pcr-learning-center/gene-expression-analysis-real-time-pcr-information/precision-qpcr.html

Services, U. D. of H. and H. (2014). *Skin Cancer as a Major Public Health Problem*. https://www.ncbi.nlm.nih.gov/books/NBK247164/

Setyawati, R., & Zubaidah, S. (2021). Optimasi Konsentrasi Primer dan Suhu Annealing dalam Mendeteksi Gen Leptin pada Sapi Peranakan Ongole (PO) Menggunakan Polymerase Chain Reaction (PCR). *Indonesian Journal of Laboratory*, *4*(1), 36. https://doi.org/10.22146/IJL.V4I1.65550

Slominski, A. T., Zmijewski, M. A., Plonka, P. M., Szaflarski, J. P., & Paus, R. (2018). How UV Light Touches the Brain and Endocrine System Through Skin, and Why. *Endocrinology*, *159*(5), 1992. https://doi.org/10.1210/EN.2017-03230

Tewari, A., Grys, K., Kollet, J., Sarkany, R., & Young, A. R. (2014). Upregulation of MMP12 and its activity by UVA1 in human skin: Potential implications for photoaging. *Journal of Investigative Dermatology*, *134*(10), 2598–2609. https://doi.org/10.1038/jid.2014.173

Vogel, C., & Marcotte, E. M. (2012). Insights into the regulation of protein abundance from proteomic and transcriptomic analyses. *Nature Reviews. Genetics*, *13*(4), 227. https://doi.org/10.1038/nrg3185

Wang, P. W., Hung, Y. C., Lin, T. Y., Fang, J. Y., Yang, P. M., Chen, M. H., & Pan, T. L. (2019). Comparison of the Biological Impact of UVA and UVB upon the Skin with Functional Proteomics and Immunohistochemistry. *Antioxidants*, *8*(12), 569. https://doi.org/10.3390/ANTIOX8120569

Wong, Q. Y. A., & Chew, F. T. (2021). Defining skin aging and its risk factors: a systematic review and meta-analysis. *Scientific Reports*, *11*(1), 22075. https://doi.org/10.1038/S41598-021-01573-Z

Wu, P. Y., Lin, T. Y., Hou, C. W., Chang, Q. X., Wen, K. C., Lin, C. Y., & Chiang, H. M. (2019). 1,2-Bis[(3-methoxyphenyl)methyl]ethane-1,2-Dicarboxylic Acid

Reduces UVB-Induced Photodamage In Vitro and In Vivo. *Antioxidants*, *8*(10). https://doi.org/10.3390/ANTIOX8100452

Yeerong, K., Chantawannakul, P., Anuchapreeda, S., Wangtueai, S., & Chaiyana, W. (2024). Optimization of Hydrolysis Conditions, Isolation, and Identification of Biologically Active Peptides Derived from Acheta domesticus for Antioxidant and Collagenase Inhibition. *Antioxidants*, *13*(3). https://doi.org/10.3390/ANTIOX13030367

Zhang, S., & Duan, E. (2018). Fighting against Skin Aging: The Way from Bench to Bedside. *Cell Transplantation*, *27*(5), 729. https://doi.org/10.1177/0963689717725755