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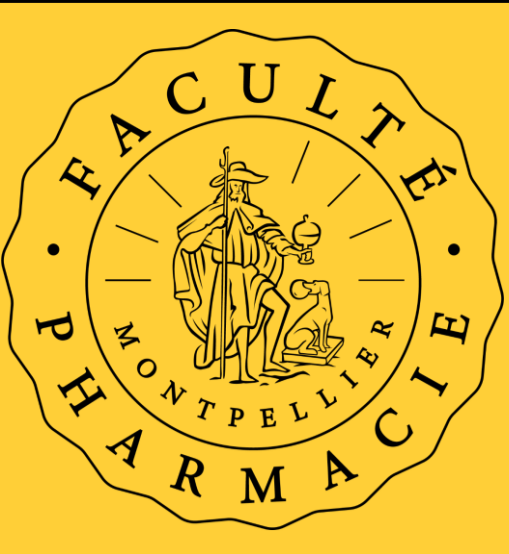
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# Knowledge on the biomedical and cosmetic usage of macrofungi

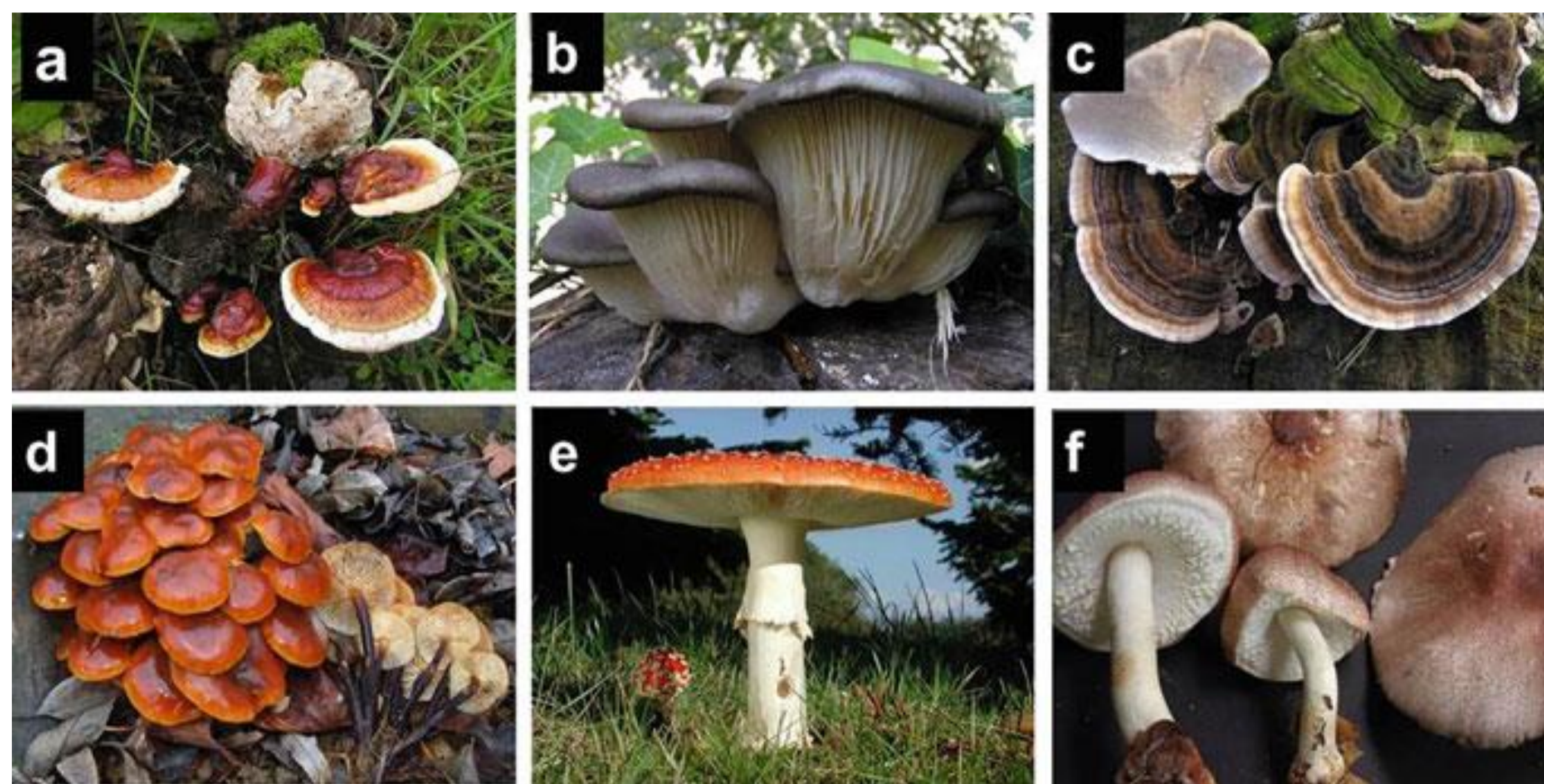
Susanna M. Badalyan<sup>1</sup>, Françoise Fons<sup>2</sup>, Morel Sylvie<sup>2</sup>, Luis Portillo-Lemus<sup>2</sup> and Sylvie Rapior<sup>2</sup>

<sup>1</sup> Laboratory of Fungal Biology and Biotechnology, Institute of Biology, Yerevan State University, Yerevan, Armenia

<sup>2</sup> Laboratoire de Botanique, Phytochimie et Mycologie, Faculté de Pharmacie, UMR CEFE, CNRS, Univ Montpellier, EPHE, IRD Montpellier, France



Fungi are ecologically diverse organisms distributed worldwide. From estimated 1.5-3 million species, about 150,000 are macrofungi (mushrooms). About 10% (14,000-16,000 species) of macrofungi are identified, of which 7000 are considered edible and 500 poisonous species. There may be as many as 700 species which are considered safe and possess around 130 pharmacological activities. The present work reviews the current state of knowledge and the main findings of previous studies on mycotherapeutics and is an update contribution to modern mycopharmacology and mycosmetology.



**Fig. 1** Fruiting bodies of agaricoid and polyporoid macrofungi with biomedical potential: (a) *Ganoderma lucidum* (Photo Courtesy of Angelini C), (b) *Pleurotus ostreatus* (Photo Courtesy of Angelini C) (c) *Trametes versicolor* (Photo Courtesy of Angelini C), (d) *Flammulina velutipes* (Photo Courtesy of Moingeon JM), (e) *Amanita muscaria* (Photo Courtesy of Callac P and Guinberteau J), (f) wild specimen CA918 *Agaricus subrufescens* (Photo Courtesy of Callac P)

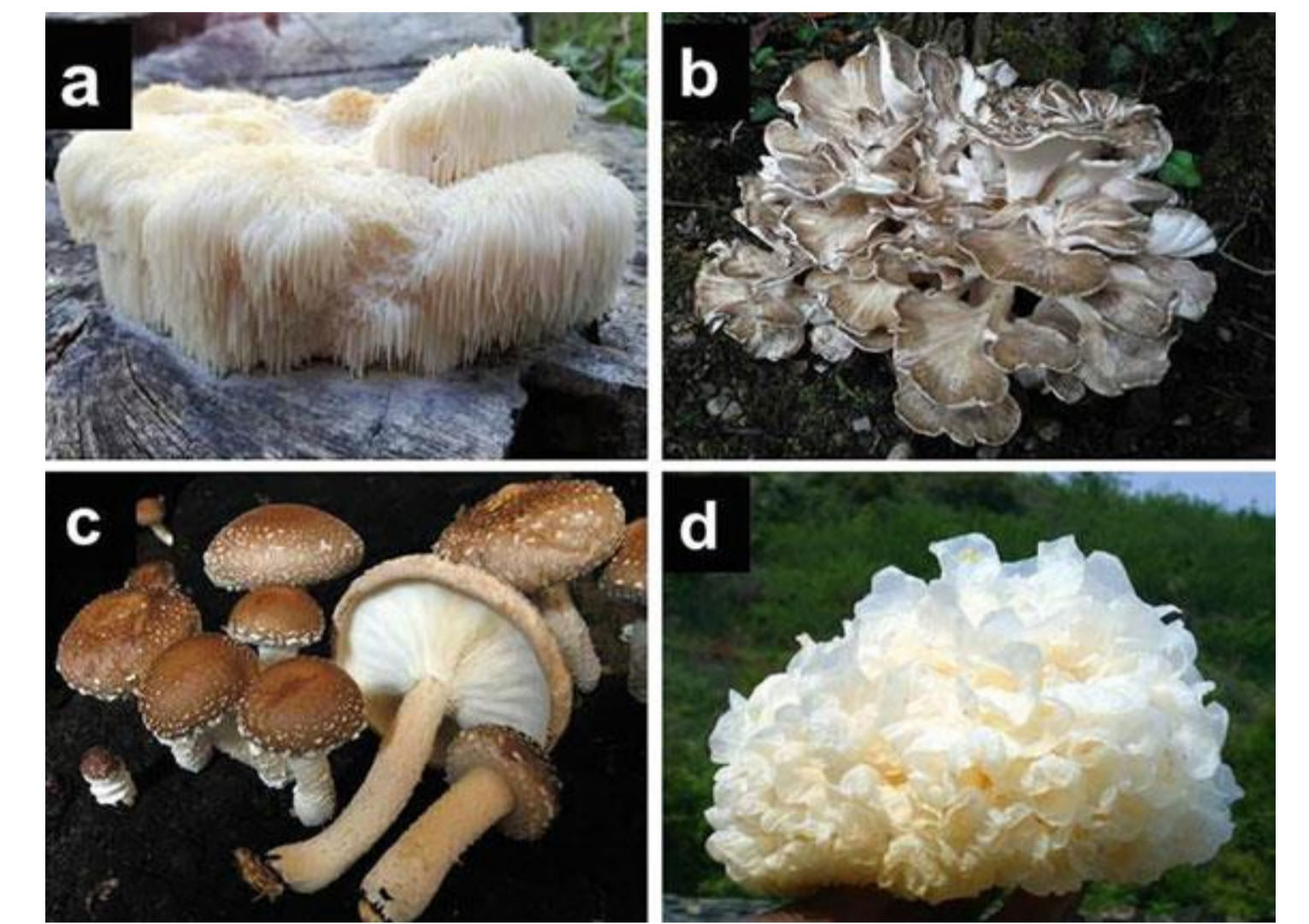
Macrofungi have widely been appreciated all over the world for their nutritional value and medicinal properties. They have been used in traditional medicine for more than 3000 years. Despite ethnomycopharmacological information and scientific data, the extensive pharmacological and biotechnological potential offered by macrofungi has not been sufficiently investigated.

Modern research has shown that they are producers of a broad spectrum of high- and low-molecular weight bioactive compounds (alkaloids, polysaccharides, phenolics, terpenoids, polyketides, cyclic peptides, lectins, ribosome-inactivating proteins, etc.) possessing analgesic, antidiabetic, anti-inflammatory, antimicrobial, antioxidant, anti-tumorous, antiviral, cardioprotective, hepatoprotective, hypocholesterolemic, antidiabetic/hypoglycemic, hypotensive, immunomodulatory, neuroprotective, mitogenic/regenerative and other pharmacological effects.

Wild and cultivable edible, and non-edible medicinal macrofungi (e.g. *Agaricus brasiliensis*, *Auricularia auricula-judae*, *Coprinus comatus*, *Cordyceps militaris*, *Ganoderma lucidum*, *Grifola frondosa*, *Hericium erinaceus*, *Flammulina velutipes*, *Inonotus obliquus*, *Lentinula edodes*, *Ophiocordyceps sinensis*, *Phellinus linteus*, *Pleurotus ostreatus*, *Trametes versicolor*, *Tremella fuciformis*) are considered valuable bio-resources to develop functional food (nutraceuticals, nutraceuticals), drugs (mycopharmaceuticals), and cosmetic products (cosmeceuticals, nutricosmetics). The pathways of biosynthesis of bioactive compounds of macrofungi and the genes behind are less understudied compared to their available extensive lists and therapeutic effects.

**Fig. 2** Fruiting bodies of edible potential neuroprotective macrofungi:

(a) *Hericium erinaceus* (Photo Courtesy of Angelini C), (b) *Grifola frondosa* (Photo Courtesy of Angelini C), (c) *Lentinula edodes* (Photo Courtesy of Angelini C), (d) *Tremella fuciformis* (Photo Courtesy of Callac P)



The advances in fungal biotechnology and cultivation will assist in the production of novel biotech products and their biomedical usage. The clinical trials and in vitro animal studies justify the experience of traditional medicine and suggest a great potential of mycopharmaceuticals for the prevention and treatment of various diseases. However, developments of standardized biotech products for further clinical trials are needed to substantiate the pharmacological properties or side effects of consumption of macrofungi before their clinical application. Thus, advances in fungal biology and biotechnology, genomics and proteomics are required for further biomedical research and usage of macrofungi.

**TABLE 1. Macrofungi incorporated in different cosmetic products (Badalyan et al, 2022)**

Mushroom species	Cosmetic Product	Cosmetic Effect
<i>Agaricus subrufescens</i>	Vitamega Facial Moisturizing Mask, Brazil	Renew and revitalize skin
<i>Albatrellus confluens</i>	REN Clean Skincare Ever calm Ultra Comforting Rescue Mask	Skin feels smooth with even tone
<i>Cordyceps sinensis</i>	Kose Sekkisei Cream, Japan	Moisturizer, suppress melanin production
<i>Ganoderma lucidum</i>	Eminence Organic Skin Care Birch Water Purifying Essence	Anti-aging, provides hydration
	Yves Saint Laurent Temps Majeur Elixir De Nuit	Anti-aging
	Dr. Andrew Weil for Origins™	Anti-aging
	Mega-Mushroom Skin-Relief Micellar Cleanser	
	Shiseido: Ultimune Power Infusing Concentrate	Anti-aging, anti-inflammatory
	Tela Beauty Organics Encore Dri Styling Cream	Hair protection
<i>Inonotus obliquus</i>	Supermood - The Perfect Day Cream	Antioxidant, skin moisturizer
	Root Science RS Reborn Organic Face Mask, U.S.	Anti-inflammatory, soothe irritated skin
<i>Lentinula edodes</i>	Griffin+row naturally effective skincare	Anti-inflammatory, skin brightening
	Aveeno Positively Ageless, Daily Exfoliating Cleanser	Anti-aging, skin lifting
	One Love Organics Vitamin D Moisture Mist, UK	Skin lightener, moisturizer and toner
<i>Pleurotus ostreatus</i>	Hankook Sansim Firming Cream	Enhances elasticity, skin tight and vitalize
<i>Polyporus umbellatus</i>	iS Clinical Active Serum	Brightens and revitalizes skin
	Alqvimia Eternal Youth Maximum recovery face cream	Brightens, unifies skin tone
<i>Schizophyllum commune</i>	Alqvimia Eternal Youth Cream Facial Máxima Regeneración, Spain	Anti-aging, skin lifting
	Sulwhasoo Hydroaid, cream, Korea	Hydrates, revitalizes skin and promotes clear
<i>Tremella fuciformis</i>	Eminence Organic Skin Care Birch Water Purifying Essence	Antioxidant, enhances skin elasticity
	Dr. Dennis Gross Skincare Alpha Beta® Pore Perfecting Cleansing Gel	Enhances skin elasticity, skin firming
	La Prairie Advanced Marine Biology Night Solution, Switzerland	Moisturizes, nourishes, revitalize
<i>Tuber spp.</i>	Black Orchid Tom Ford, Jo Malone Red Truffle 21, Estee Lauder Re-Neutriv' skin cream, Perigold	Perfumes with truffles' aroma, moisturizes, nourishes
	Truffoire truffle magnetic face mask	

New glycoprotein complex from Maitake helps to maintain healthy cardiovascular function.



Anticancer Maitake-Shiitake Tea

Tea, spore powder and extract of *G. lucidum*

Biotechnologically cultivated *Tremella fuciformis* (a) and *Hericium erinaceus* (b)

