

Sun Exposure and Fat Loss

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“Eureka!” is heard as scientists uncover new discoveries, the cry accompanied by a cartoon light bulb appearing overhead. If that cartoon scene holds a clue to fat loss, it may be the light cast by the bulb. Insane, right? Surely fat loss is not as simple as upgrading from 60 to 75 watts? Of course it isn’t, but there is a body of evidence suggesting that fat loss may be related to light exposure, more specifically, sun exposure.

Understanding the process involved is at first complex, but with a little effort, it becomes clear. In fact, don’t be surprised if you need to read this article two or three times to fully understand it, as it deals with true cutting-edge science. The process likely evolved eons ago, when man was just learning to walk upright and considered fire to be a message from the gods. Before the advent of air-conditioning, forced-air furnaces and grocery stores, mankind responded to the changes in season just the way animals continue to do today.

The only measure of time available to primitive man was the length of the day, with shorter days announcing the coming of winter and a period of famine (starvation). As the days lengthened, warmer weather approached and food became more readily available. Man responded to the coming of winter by storing fat and burning fewer calories, while summer required him to shed those excess pounds to hunt and gather without becoming prey to carnivorous predators. The question arises: How did the sun signal primitive man to store fat for the winter and shed fat in the summer?

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Pieces of a Puzzle

The path from sunshine to fat loss is like a puzzle in which all the pieces have to be identified and put together to form the picture. A close look at the pieces will show how they fit together and then the picture will be clear.

The sun is a source of ultraviolet (UV) rays, which cause oxidative stress (molecular injury) on the skin cell membrane and can lead to skin damage or cancer.^{1,2} The body has a mechanism for protecting against UV-caused skin damage by increasing the amount of a protective pigment called eumelanin.^{3,4} Eumelanin pigment builds up in the skin following UV exposure; this process is easily recognized by every sunbather as "tanning." Sunshine and tanning seems like a simple cause-and-effect relationship, but there are a number of steps involved before the appearance of the first freckle. Even more incredible is the far-reaching impact of the UV-tanning cascade on other tissues, including fat cells and the brain.

When UV rays strike the skin cell surface, they turn on certain genes within the cell's DNA.^{4,5} These genes produce a pre-prohormone called proopiomelanocortin (POMC).^{4,5} POMC is broken down to smaller fragments, including a class of hormones called melanocortins.⁴⁻⁸ Specific melanocortins, including μ -MSH (melanocyte stimulating hormone) stimulates the actual eumelanin production, resulting in a tan.^{4,9} Not surprisingly, eumelanin is an antioxidant, protecting against further UV-related damage, which explains why the body responds with a tan when assaulted by UV rays.³

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This describes how and why the sun tans the skin, but not how sun exposure causes fat loss. The hormones involved in the body's response to sun exposure, the melanocortins, are players in other tissues besides the skin.

A great deal of attention has been paid to a recent discovery in fat cell metabolism—a hormone known as leptin. Leptin is produced by the fat cells in abundance when fat content is high, and leptin levels drop as body fat is

lost.10-12 Leptin, when administered as a drug, causes normal humans and rats to eat less and burn more calories.10-12 However, attempts to turn leptin into a fat loss drug have failed because most obese people do not respond to leptin treatment. This is called leptin resistance.10,12,13 Leptin research has continued and scientists have discovered that leptin acts upon certain areas of the brain, stimulating the production of — yup— melanocortins.10-12,14

These melanocortins, the same hormones produced by the skin, suppress the appetite centers in the brain, decreasing the amount of food eaten and causing weight loss.10,12 Animal experiments injecting melanocortins directly into the brain have proven the actions and effectiveness of these hormones.10,15,16 However, there are always checks and balances in the body, and the leptin-melanocortin system is no exception. A separate hormone, called agouti, is also present in the same areas of the brain and competes with the melanocortins.7,10,11,15-18 When the balance is tipped towards agouti, the subject becomes hungry, increasing food intake and gaining weight.10,11,14,16,18 So, leptin increases when the body gets fatter, causing the brain to produce melanocortins, which suppress the appetite. To avoid losing weight too rapidly, a counter-hormone called agouti competes with the melanocortins when body fat drops, restoring the appetite.

Research has shown that melanocortins injected into the body affect the brain and weight gain, just like they do when injected directly into the brain.6,8,13,19-21 This suggests that melanocortins produced in the skin may circulate through the bloodstream and affect the brain and other tissues.

Interestingly, the same hormones that cause tanning also affect the appetite, but fat loss involves more than controlling the appetite. Melanocortins and agouti, the same hormones competing to control the appetite in the brain, both act on the fat cell.6,17,22-24 Fat cells contain receptors that respond to agouti by increasing the concentration of calcium in the fat cell.22,23 Increased calcium inside the fat cell promotes lipogenic process and enzymes, creating more fat inside the cell, decreasing fat loss.22,23,25,26 When the balance outside the cell favors melanocortins, calcium is prohibited from entering the fat cell and stored fat is broken down and released, to be burned as fuel by the body.6,23,24

The Vitamin D Factor

The actions of melanocortins and agouti on the fat cell appear to involve modifying the effects of vitamin D. Vitamin D is created in the skin, in a reaction involving sun exposure.25 It is sensible that the skin would generate and release a messenger hormone (vitamin D is a steroid molecule) that acts upon the fat cell. During winter, which would be anticipated by a shorter period of daylight, fat would function both as a source for stored energy and as a thermal insulator, protecting against the oncoming cold weather. During the summer, an individual needs to shed the blanket of fat to be more mobile and to improve heat loss. Failure to lose the stored fat would have put primitive man at a disadvantage, making him slow and prone to heat exhaustion when hunting or avoiding predators.

In addition to these effects, it appears that melanocortin is also able to increase the body's metabolism, increasing the rate at which calories are burned. Animal data suggest that in

the presence of melanocortins, uncoupling protein-3 is increased.^{13,15,19,20} Uncoupling proteins make the body less efficient, causing calories to be released as heat, rather than used for energy production. Adding to the metabolic increase is the effect of melanocortins on thyroid hormone release. When exposed to melanocortins, the thyroid increases its output, further increasing the body's metabolism and fat burning rate. ²⁶

A Potent Mechanism

So many pieces, but when put in place, they describe a potent mechanism by which the body reacts to the anticipated onset of famine (winter) and feasting (summer). Sunlight "irritates" the skin, turning on a genetic sequence, creating melanocortins. These melanocortins increase the skin's pigment (eumelanin) but also circulate throughout the body, possibly affecting other systems. Melanocortins have been shown to affect fat storage and release, appetite and the metabolic rate of the entire body. Within the brain, melanocortin production is influenced by the amount of fat stored by the body, and appears to be involved in weight maintenance, even in the absence of sunlight.

Apparently the process has not escaped the attention of several pharmaceutical companies who have rushed to patent a number of drugs that act like the naturally produced melanocortins.²⁷⁻³³ Much of the research is currently focused on the use of melanocortin-like drugs to treat obesity^{7,21,27,34} and impotence²⁸⁻³⁸ (yes, it increases erections too), in addition to the tanning effect, leading the press to call these drugs "Barbie drugs" after the ever-beautiful Barbie Dolls.³⁹

When considered as a whole, this evidence would suggest that increasing sun exposure, sufficient to cause a tanning response, may support fat loss efforts. Tanning might make dieting easier by decreasing the appetite, reducing food intake and increasing the use of stored fat for calories. The stored fat may be more readily released and burned as fuel. Those who do not tan easily, such as redheads and those with fair skin, are unlikely to benefit to the same degree.^{1,2,9,40,41}

Tanning is not without risk, as skin damage and cancerous changes increase with prolonged and excessive sun exposure. It's recommended that a skin cancer screen be performed prior to tanning and if any skin lesions or changes are noted.

References

- Healy E, Flannagan N, et al. Melanocortin-1 receptor gene and sun sensitivity in individuals without red hair. *Lancet* 2000 Mar 25;355(9209):1072-3.
- Rees JL, Healy E. Melanocortin receptors, red hair, and skin cancer. *J Invest Dermatol Symp Proc* 1997 Aug;2(1):94-8.
- Pawelek JM. Approaches to increasing skin melanin with MSH analogs and synthetic melanins. *Pigment Cell Res* 2001 Jun;14(3):155-60.
- Slominski A, Wortsman J, et al. Corticotropin releasing hormone and proopiomelanocortin involvement in the cutaneous response to

- stress. *Physiol Res* 2000 Jul;80(3):979-1020.
- Suzuki I, Kato T, et al. Increase of pro-opiomelanocortin mRNA prior to tyrosinase, tyrosinase-related protein-1, dopachrome tautomerase, Pmel-17/gp100, and P-protein mRNA in human skin after ultraviolet B irradiation. *J Invest Dermatol* 2002 Jan;118(1):73-8.
- Stephenson JS. Knockout Science: chubby mice provide new insights into obesity. *JAMA* 1999 Oct 27;282(16):1507-8.
- MacNeil DJ, Howard AD, et al. The role of melanocortins in body weight regulation: opportunities for the treatment of obesity. *Eur J Pharmacol* 2002 Apr 12;440(2-3):141-57.
- Yaswen L, Diehl N, et al. Obesity in the mouse model of pro-opiomelanocortin deficiency responds to peripheral melanocortin. *Nat Med* 1999 Sep;5(9):1066-70.
- Suzuki I, Im S, et al. Participation of the melanocortin-1 receptor in the UV control of pigmentation. *J Invest Dermatol Symp Proc* 1999 Sep;4(1):29-34.
- Marks DL, Cone RD. Central melanocortins and the regulation of weight during acute and chronic disease. *Recent Prog Horm Res* 2001;56:359-75.
- Zemel MB. Agouti/melanocortin interactions with leptin pathways in obesity. *Nutr Rev* 1998 Sep;56(9):271-4.
- Lu H, Buisson A, et al. Leptin resistance in obesity is characterized by decreased sensitivity to proopiomelanocortin products. *Peptides* 2000 Oct;21(10):1479-85.
- Cettour-Rose P, Rohner-Jeanrenaud F. The leptin-like effects of 3-d peripheral administration of a melanocortin agonist are more marked in genetically obese Zucker (fa/fa) than in lean rats. *Endocrinology* 2002 Jun;143(6):2277-83.
- Adage T, Scheurink AJ, et al. Hypothalamic, metabolic, and behavioral responses to pharmacological inhibition of CNS melanocortin signaling in rats. *J Neurosci* 2001 May 15;21(10):3639-45.
- Hwa JJ, Ghibaudi L, et al. Central melanocortin system modulates energy intake and expenditure of obese and lean Zucker rats. *Am J Physiol Regul Integr Comp Physiol* 2001 Aug;281(2):R444-51.
- Fan W, Boston BA, et al. Role of melanocortinergic neurons in feeding and the agouti obesity syndrome. *Nature* 1997 Jan 9;385(6612):165-8.
- Voisey J, van Daal A. Agouti: from mouse to man, from skin to fat. *Pigment Cell Res* 2002 Feb;15(1):10-8.
- Ollman MM, Wilson BD, et al. Antagonism of central melanocortin receptors in vitro and in vivo by agouti-related protein. *Science* 1997 Oct 3;278(5335):135-8.
- Chen AS, Metzger JM, et al. Role of the melanocortin-4 receptor in metabolic rate and food intake in mice. *Transgenic Res* 2000 Apr;9(2):145-54.
- Pierroz DD, Ziotopoulou M, et al. Effects of acute and chronic administration of the melanocortin agonist MTII in mice with diet-induced obesity. *Diabetes* 2002 May;51(5):1337-45.
- Dhillo WS, Bloom SR. Hypothalamic peptides as drug targets for obesity. *Curr Opin Pharmacol* 2001 Dec;1(6):651-5.
- Kim JH, Kiefer LL, et al. Agouti regulation of intracellular calcium: role of melanocortin receptors. *Am J Physiol* 1997 Mar;272(3 Pt 1):E379-84.
- Xue B, Moustaid N, et al. The agouti gene product inhibits lipolysis in human adipocytes via a Ca²⁺ dependent mechanism. *FASEB J* 1998

Oct;12(13):1391-6.

24

Boston BA. The role of melanocortins in adipocyte function. Ann N Y Acad Sci 1999 Oct 20;885:75-84.

25

Ganong WF. Review of Medical Physiology, 19th ed. — Hormonal control of calcium metabolism & the physiology of bone (chapter 21). Lange Medical Books/McGraw-Hill, New York, 1999:371-2.

26

Krotkiewski M. Thyroid hormones in the pathogenesis and treatment of obesity. Eur J Pharmacol 2002 Apr 12;440(2-3):85-98.

27

Cone RD, Fan W, et al. US Patent 6,476,187. Methods and reagents for discovering and using mammalian melanocortin receptor agonists and antagonists to modulate feeding behavior in animals. 2002 November 5.

28

Bakshi RK, Nargund RP, et al. US Patent 6,376,509. Melanocortin receptor agonists. 2002 April 23.

29

Nargund RP, Ye Z, et al. US Patent 6,410,548. Spiropiperidine derivatives as melanocortin receptor agonists. 2002 June 25.

30

Hadcock JR, Swick AG. US Patent 6,451,783. Treatments for obesity and methods for identifying compounds useful for treating obesity. 2002 September 17.

31

Palucki B, Barakat K, et al. US Patent 6,458,790. Substituted piperidines as melanocortin receptor agonists. 2002 October 1.

32

Palucki B, Nargund R. US Patent 6,472,398. Spiropiperidine derivatives as melanocortin receptor agonists. 2002 October 29.

33

Lee F, Huszar D, et al. US Patent 5,932,779. Screening methods for compounds useful in the regulation of body weight. 1999 August 3.

34

Anonymous.

Press Release. Competitive Technologies client to be interviewed on sun-less tanning and sexual dysfunction technology. 2002 July 29. Available through <http://biz.yahoo.com/pz/020729/30014.html> accessed February 3, 2003.

35

Vemulapalli

R, Kurowski S, et al. Activation of central melanocortin receptors by MT-II increases cavernosal pressure in rabbits by the neuronal release of NO. Br J Pharmacol 2001 Dec;134(8):1705-10.

36

Wesselis

H, Grainek D, et al. Effect of an alpha-melanocyte stimulating hormone analog on penile erection and sexual desire in men with organic erectile dysfunction. Urology 2000 Oct 1;56(4):641-6.

37

Wesselis

H, Levine N, et al. Melanocortin receptor agonists, penile erection, and sexual motivation: human studies with melanotan II. Int J Impot Res 2000 Oct;12 Suppl 4:S74-9.

38

Anonymous.

Press Release. Competitive Technologies's licensee reports PT-141 data for males. 2003 January 23. Available through http://biz.yahoo.com/prnews/030123/nyth158_1.html accessed February 3, 2003.

39

Usborne

D. Paradise in a pill? The Independent. 2002 July 31. Available through <http://news.independent.co.uk/world/australia/story.jsp?story=319949> accessed February 3, 2003.

40

Flanagan

N, Ray AJ, et al. The relation between melanocortin 1 receptor genotype and experimentally assessed ultraviolet radiation sensitivity. J Invest Dermatol 2001 Nov;117(5):1314-7.

41

Sturm

RA. Skin colour and skin cancer – MC1R, the genetic link. Melanoma Res 2002 Sep;12(5):405-16.