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Green Tea: New Benefits from an Old Favorite?

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Reviewed and recertified January 2009
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Course ID code: GRT09

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Level I
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Learning Objectives

At the conclusion of this course, the student will be able to:

1. Name the plant from which tea is produced.
2. Describe the three major types of tea and how each tea is produced.
3. Name at least three countries where green tea is primarily consumed.
4. List the four categories of polyphenols and name at least one class of polyphenols within each category.
5. Name at least four food sources of flavonoids.
6. Identify the major polyphenols of green and black tea.
7. Describe the antioxidant properties and binding effect of the polyphenols in tea.
8. Discuss at least three proposed mechanisms of actions of tea against cardiovascular disease and cancer.
9. Explain the relationship between tea drinking and incidence of cardiovascular disease, including heart attacks.
10. Explain how tea appears to be beneficial for dental health, weight control, preventing kidney stones, and possibly protecting against HIV infection.
11. Describe the health benefits of kombucha, a probiotic tea.
12. Inform clients and patients about what the scientific literature states about how much tea should be consumed as well as communicate the health benefits and possible drug interactions of tea.

Green tea has been touted as a remedy for centuries. Tea drinking can be traced back at least 4,000 years in China, where an emperor discovered tea accidentally, according to legend. Traditional Chinese medicine recommends drinking green tea to prevent and treat a variety of ailments, including headaches, body aches and pains and digestive problems. It is believed to improve immune function, aid detoxification, boost energy and prolong life. As we'll see, the traditions may be right!

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Although green tea has been touted as a remedy for centuries, it is only within the past several years that the consumption and popularity of green tea has soared. "Green is gold right now." says Brian Keating, president and founder of the Seattle-based tea think tank Sage Group International. Green tea, once only available in Asian restaurants, is now everywhere. The addition of a green tea frappuccino to the Starbucks' menu has been likened to Oprah choosing a new book for her book club. Sales of green tea have grown steadily since 1997. In 2003, green tea sales generated about $625 million, or 12.5 percent of the $5.5 billion in total tea sales. In addition, green tea can now be found in moisturizers, diet pills, ice cream, and pet food (Onge, 2005; Kativar, *et al*., 2000).

The popularity of green tea is linked to the discovery, isolation, and identification of phytochemicals, physiologically active ingredients, specifically polyphenols, which are believed to protect against heart disease, cancer and promote wellness. Consumers consider green tea to be a health drink, not just another beverage. An increasing variety of teas can be found alongside juices, vitamin waters, and soft drinks in the refrigerated sections of grocery and convenience stores. The popularity of green tea is likely to continue as new studies are released that support green teas functionality.

"Tea" is a collective term for a wide variety of herbal concoctions, including smartly packaged and cleverly marketed blends of all kinds. For this course, tea will refer to the water extract of the dried leaves of the plant *Camellia sinensis*, a tropical evergreen shrub of the *Theaceae* family. There are three main types of tea: black tea, green tea, and oolong tea. Most tea produced is black tea, which represents 76 to 78 percent of the tea produced and consumed worldwide. Green tea represents about 20 to 22 percent of the tea produced worldwide. Oolong tea represents only about 2 percent (McKay and Blumberg, 2002).

Tea is second only to water in popularity worldwide. It is estimated that about 3 billion kg of tea are produced and consumed annually. The average per capita consumption of tea is about 120 ml or about a half cup per day (McKay and Blumberg, 2002; Yang and Landau, 2000).

The type of tea consumed varies in different countries. Black tea is consumed primarily in Western countries and some Asian countries, while green tea is primarily consumed in China, Japan, India, and in a few countries in North Africa and the Middle East. Oolong tea is primarily produced and consumed in southeastern China and Taiwan (McKay and Blumberg, 2002; Mukhtar and Ahmad, 2000).

In this course, the focus will be on green and black tea, rather than oolong. It is important to understand the differences in how the leaves of the plant *Camellia sinensis* are processed.

The first step in the production of black tea is allowing tea leaves to wither or dry. Their moisture content is reduced and they lose nearly half of their original weight. Next, the withered leaves are rolled and crushed, which initiates fermentation. Oolong tea is made by in the same way as black tea, except that shortly after rolling the leaves they are fired to stop the oxidation process and dry the leaves. Thus, oolong tea is about half as fermented as black tea (Mukhtar and Ahmad, 2000).

In contrast, green tea is made from freshly harvested leaves that are rapidly steamed or pan-fried. This inactivates the enzymes present in the leaves, which prevents fermentation, while producing a dry and stable product (Yang, *et al*., 2000; Mukhtar and Ahmad, 2000).

These different manufacturing processes alter the chemical composition and properties of each of these teas (McKay and Blumberg, 2002). There are a variety of other factors which affect the chemical composition of tea, including climate, season, horticultural practices, and the type and age of the plant (Mukhtar and Ahmad, 2000). (Like wine buffs, tea connoisseurs have their favorites, often identified by region of origin.)

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Categories, Classes and Food Sources of Polyphenols

Category	Classes	Major Food Sources
Phenolic acids	• Ferulic acid	Dietary fiber – hemicelluloses
	• Caffeic acid, - Chlorogenic acid	Many fruits and vegetables, coffee
	• Condensed tannins	Mango fruit
	• Hydrolyzable tannins: - Gallotannins - Ellagitannins	Blackberries, raspberries, strawberries, wine, brandy aged in oak barrels
Flavonoids	• Flavones	Sweet red pepper, celery
	• Flavonols - Quercetin	Tea, onions, apples, many other fruits and vegetables
	• Flavanols: - Catechins: epicatechin (EC) epicatechin-3-gallate (ECG) epigallocatechin (EGC) epigallocatechin-3-gallate (EGCG)	Tea, especially green tea, chocolate, cocoa
	• Flavanones: - Hesperetin	Oranges, citrus fruits
	• Isoflavones: - Genistein - Daidzein	Soybeans, soy protein-containing foods
	• Anthocyanins: - Cyanidin	Red fruits: cherries, plums, strawberries, raspberries, blackberries, grapes, red and black currants
	• Proanthocyanidins	Apples, pears, grapes, red wine, tea
Lignans	• Enterodiol	Flaxseed, flaxseed oil
Stilbenes	• Resveratrol	Red wine

Note: These are major categories.This is not an exhaustive list.

Adapted from: Scalbert and Williamson, 2000.

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For as long as people have been drinking tea, there have been health benefits associated with it. However, it has only been within the past 20 to 30 years that scientific studies have been conducted to investigate the validity of these claims. Many animal studies, and recently an increasing number of human studies including epidemiological studies and clinical trials, have examined the relationship between tea drinking and health. Although there are many inconsistencies, we can safely say that tea drinking is associated with protection from heart disease and cancer, and the effects of viruses and certain bacteria. It also relieves some of the discomfort of arthritis (Nagao, *et al.,* 2007; St-Onge, 2005; Lambert, *et al.*, 2005; Adhami, *et al.*, 2003; McKay and Blumberg, 2002).

According to John Weisburger at the American Health Foundation, "Tea is beating all scientific expectations as the most potent health beverage ever" (Carper, 2001). In the following sections the functional components and health benefits of tea will be reviewed and discussed.

Functional components

• **Polyphenols**. Tea is a rich source of a group of phytochemicals known as polyphenols, particularly the flavonoids. Polyphenols are strong antioxidants. They are the most abundant antioxidants in our diets, as several thousand natural polyphenols have been identified in plants. Many phytochemicals are responsible for an astringent taste in foods. For example, tannins are the compounds that give tea a slightly astringent taste, especially when it is brewed to be strong (Scalbert and Williamson, 2000).

Antioxidants protect against the damage that can be caused by free radicals, which are unstable molecules in the body. Antioxidants — particularly vitamins A, C, E, and beta-carotene and the mineral selenium — are known to counteract free radicals. The chemical structure of polyphenols contributes to their antioxidant properties and makes them distinct from other antioxidants (Scalbert and Williamson, 2000).

Polyphenols include four categories of compounds that are grouped according to their carbon-atom "skeleton." These four categories are phenolic acids, flavonoids, lignans, and stilbenes. Within these categories there are several classes of compounds. The following chart lists the categories and classes of polyphenols and their food sources, which are further discussed below.

• **Flavonoids**. The most abundant polyphenols in our diets, flavonoids are synthesized in substantial amounts by a variety of plants. More than 4,000 flavonoids have been identified. Flavonoids are divided into several different groups or classes based on the degree of oxidation of the oxygen heterocycle. The classes of flavonoids include **flavones, flavanols** (yes, there are different flavonoids with very similar names), **quercetin, isoflavones, flavanones, proanthocyanidins** and **anthocyanins** (Cabrera, *et al.,* 2006; Scalbert, *et al.,* 2005; Scalbert and Williamson, 2000).

Some facts about each:

- Flavones are less abundant in foods and are found primarily in sweet red pepper and celery.
- Flavanols include catechins that are abundant in tea, red wine, and chocolate.
- Quercetin is the primary flavonol found in fruits, vegetables (particularly onions), and beverages.
- Isoflavones are found in soy protein and foods containing soy protein.
- Flavanones are found in oranges.
- Proanthocyanidins, which are found in apples, pears, grapes, red wine, and tea, are the substances responsible for the astringency of food.
- Anthocyanins, the red pigments of fruits, are found in cherries, plums, strawberries, raspberries, blackberries, grapes, and red and black currants (Scalbert and Williamson, 2000).

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It is difficult to estimate the polyphenol content of foods, due to the diversity of their chemical structures and the fact that most data on polyphenol content of foods are from scattered sources. However, it is estimated that two-thirds of the polyphenols in our diets are flavonoids; about one-third of the polyphenols are phenolic acids (Scalbert and Williamson, 2000).

However, these estimates may vary depending on a person's consumption of coffee, red wine, tea, chocolate or beer. The intake of phenolic acids will most likely be greater than intake of flavonoids in persons who are heavy coffee drinkers. Persons who frequently consume fruits, red wine, tea, chocolate, or beer will have higher intake of flavonoids, specifically the flavonols, flavanols, anthocyanins, and proanthocyanidins classes of flavonoids. Studies have found a positive association between dietary flavonoid intake and overall good health (Cabrera, *et al.,* 2006; Scalbert, *et al.,* 2005; Scalbert and Williamson, 2000).

The bioavailability, metabolism, and absorption of polyphenols are determined by their chemical structure. Our information on bioavailability is limited, as few studies have been done. Most of the polyphenols we ingest, about 75 percent, is not found in urine, so it is suggested that they are either absorbed through the GI tract, absorbed and excreted in bile, or metabolized by the colonic microflora or other body tissues. It is known that maintaining high plasma levels of polyphenols requires repeated intake over time (Scalbert and Williamson, 2000).

Green tea contains a variety of polyphenols, including phenolic acids and flavonoids, which are sometimes referred to as the *catechins*. The major catechins found in green tea include at least four subgroups: epicatechin (EC), epicatechin-3-gallate (ECG), epigallocatechin (EGC), and epigallocatechin-3-gallate (EGCG).

Of these, EGCG is the most abundant and has received the most attention in scientific studies, especially for its cancer-inhibitory activity and its possible role in weight loss and management (Nagao, *et al.,* 2007; St-Onge, 2005; Adhami, *et al*., 2003; Yang and Landau, 2000; Yang, *et al*., 2000; Chung, *et al*., l998; Katiyar and Mukhtar, 1996). Tea also contains other categories of flavonols, such as quercetin, but at lower levels (Lambert, *et al.,* 2005; Adhami, *et al*., 2003; Yang, *et al*., 2000).

The catechin content of tea may depend on the geographical location of origin, growing conditions, and how the leaves were processed prior to drying. The polyphenolic content represents about 30 percent of the dry weight of green tea (Mukhtar and Ahmad, 2000).

The primary catechins in black tea include theaflavins and thearubigins. Fermentation of the polyphenols occurs during crushing and rolling of the leaves. During the process of making black tea the catechins are converted to theaflavins and thearubigins, the phytochemicals that give black and oolong tea their characteristic color and flavor (Mukhtar and Ahmad, 2000).

Thearubigins are the major polyphenols in black tea, representing more than 20 percent of the solids in brewed tea (Yang and Landau, 2000). Theaflavins, which account for 2 to 6 percent of the solids in brewed black tea, include theaflavin, theaflavin-3-gallate, theaflavin-3'-gallate, and theaflavin-3, 3'-digallate. Tea contains caffeine, usually representing 3 to 6 percent of the dry weight of brewed tea. In addition, tea contains volatile oils, vitamins, and minerals. The chart on the following page has a summary of tea facts.

The flavonoid content of tea, in beverage form, varies depending on the type of tea — blended, decaffeinated, herbal, or instant — and how the tea is prepared (amount of tea used, brewing time, and water temperature). Brewed hot tea contains the highest concentration of flavonoids. Instant tea contains lower concentrations and even lower concentrations are in iced and ready-to-drink tea. "Herbal

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teas" do not contain catechins or caffeine. Decaffeinated tea has slightly less catechin content than black tea (McKay and Blumberg, 2002). It is estimated that a cup of green tea has 375 mg of catechins. In comparison, a glass of red wine has 300 mg of catechins (Atukorale, 2002).

Steeping green or black tea leaves in hot water for 3 to 5 min. is typically how the beverage is prepared. In general, in the preparation of one serving of tea the proportion of tea to water is 1 gm of tealeaf to 100 ml water. A typical serving of tea contains about 250 to 350 mg tea solids (Yang, *et al.*, 2000).

The brewing time affects the antioxidant potential of tea. Brewing tea for 5 minutes releases 85 percent of the antioxidant potential of tea and brewing for an additional 5 minutes releases another 15 percent. Black tea was found to have more antioxidant capacity than green tea. However, green tea has more of the antioxidant EGCG than black tea (Atukorale, 2002).

Tea Facts

Botanical name: ***Camellia sinensis***

Calories (8 oz): 2 Caffeine content (8 oz): 34 mg

	Green	Black	Oolong
Manufacturing Process	Leaves are steamed or pan-fried; no fermentation occurs	Leaves are withered, rolled & crushed; fermentation of polyphenols occurs	Leaves are withered,rolled & fired before fermentation can occur
Major Polyphenols	Epicatechin Epicatechin-3-gallate Epigallocatechin Epigallocatechin-3- gallate	Theaflavin Thearubigin	
Countries primarily consumed	China, Japan, India, North Africa, Middle East	Western countries, some Asian countries	Southeastern China, Taiwan

www.medicinalfoodnews.com, Date accessed, 5/01; Mukhtar and Ahmad, 2000; McKay and Blumberg, 2002.

Fighting "Free Radicals"

Tea polyphenols have the ability to scavenge reactive oxygen species (ROS), known as "free radicals," and nitrogen species. Free radicals are by-products of normal metabolism in the body. Our bodies are exposed to environmental sources of free radicals, such as cigarette smoking and chemical pollutants. ROS and nitrogen species are known to attack the lipid membranes and damage cell DNA. The damage caused by ROS is known to initiate the development of cancer and heart disease. Antioxidants can deactivate or destroy ROS, thus preventing them from damaging cells.

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A variety of *in vitro* studies have found that the flavonoids in green and black tea are effective antioxidants against free radicals or ROS. Cao, Sofic, and Prior (1996) used the Oxygen Radical Absorbance Capacity (ORAC) assay to investigate the antioxidant activity of tea and various vegetables. In this study, green and black tea were found to have a much higher antioxidant activity against peroxyl radicals than garlic, kale, spinach, and Brussels sprouts, which are the vegetables with the highest ORAC values. Green tea was found to be more potent than black tea using the Ferric Reducing Ability of Plasma (FRAP) assay (Langley-Evans, 2000).

Another study, which used the Tocol Equivalent Antioxidant Capacity (TEAC) assay, found epicatechin and catechin are among the most potent of 24 plant-derived polyphenolic flavonoids (Rice-Evans, *et al.*, l995).

It is important to note that studies investigating the antioxidant properties of flavonoids do not take into account their bioavailability and/or metabolism (McKay and Blumberg, 2002).

The findings of several clinical studies indicate that within 30 to 60 min. of consumption of a single dose of tea, either 300 ml of brewed tea or 2 gm of green or black tea solids, the plasma antioxidant capacity of healthy adults was improved (Benzie, *et al.*, l999; Sung, *et al.*, 2000; Rice-Evans, *et al.*, l995; Lean, *et al.*, l999; McKay and Blumberg, 2002).

In a small clinical trial green tea extract supplements, given to 30 healthy individuals, were found to yield a small, but significant increase in plasma antioxidant activity in comparison to drinking green tea (Hennings, *et al.*, 2004).

Binding Effect

Polyphenols have a strong binding affinity for metal ions, especially iron, thus preventing peroxidative reactions (Yang, *et al.*, 2000). The binding effect of polyphenols may affect the absorption of certain minerals and may have an effect on the absorption of these nutrients. Tea drinking has been shown to decrease the absorption of nonheme iron, especially when consumed together. Food sources of nonheme iron include lentils, chickpeas, kidney beans, pinto beans, navy beans, black beans, boiled spinach and beet greens, blackstrap molasses, iron-fortified cereals, and dried apricots. The absorption of heme iron, found primarily in red meat, is not affected by tea intake (Yang and Landau, 2000).

Tea polyphenols also have a strong affinity for proteins and can bind to a protein in more than one place. Polyphenols are especially attracted to proteins with a high content of the amino acid, proline. These proteins include milk caseins, gelatin and salivary proline-rich proteins. It is unknown if this strong affinity for proteins impairs protein absorption. It is this affinity for proteins that is thought to contribute to the ability of tea polyphenols to inhibit certain enzymes involved in carcinogenesis (Yang and Landau, 2000).

It is the antioxidant potential of the flavonoids in tea that is linked to the proposed health benefits of tea. These properties of tea polyphenols and their influence on disease prevention will be discussed in detail in the following section.

Health Benefits

• **Cardiovascular disease.** Many epidemiological studies have suggested that tea intake has a protective effect against cardiovascular disease (CVD), including atherosclerosis, coronary heart disease (CHD), mortality, stroke incidence, and possibly high cholesterol and high blood pressure (Nagao,

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et al., 2007; Cabrera, *et al.,* 2006; Nagao, *et al.*, 2005; Maron, *et al.*, 2003; Vita, 2003; McKay and Blumberg, 2002; Yang and Landau, 2000). Several published reports by Hertog and his colleagues noted an inverse relationship between flavonol intake and CVD in Europe. Black tea, apples, and onions are the primary sources of dietary flavonols in Europe (Hertog, *et al.*, 1993, 1995 and l997; Keli, *et al.*, l995; McKay and Blumberg, 2002). In Western countries black tea is a primary source of dietary flavonol intake. Geleijnse, *et al.* (2002) also observed an inverse relationship between tea and flavonoid intakes and CVD, particularly with incidence of myocardial infarction (MI) or heart attack.

However, several epidemiological studies have reported a positive association between tea intake and total mortality and coronary morbidity (Cabrera, *et al.,* 2006; Woodward and Tunstall-Pedoe, l999; Hertog, *et al.*, l997). The chart on the following page summarizes the findings of these epidemiological studies.

The discrepancy and conflicting findings between the first four studies and the last two studies cited above could largely be due to variations in socioeconomic and lifestyle factors between the countries. For instance, in Wales and Scotland tea drinking is more positively associated with lower socioeconomic class and with people who have less healthy lifestyles as determined by a higher prevalence of smoking and higher dietary fat intake.

In contrast, tea drinkers in the Netherlands tend to be more educated, consume less dietary fat, alcohol and coffee, smoke less, and have a lower body mass index (McKay and Blumberg, 2002).

The Boston Area Health Study, a case-control study, reported that men and women who drank one or more cups of tea daily had a 44 percent lower risk of MI than persons who drank no tea at all (Sesso, *et al.*, l999). A Japanese cohort study of 8,552 Japanese adults found that daily intake of more than 10 cups of green tea significantly decreased the risk of death from CVD in men and was beneficial in women (Nakachi, *et al.*, 2000). However, a more recent study of 38,000 women, followed for over 6 years, found that flavonoid intake from tea was not strongly associated with decreasing risk of cardiovascular disease (Sesso, 2003).

A meta-analysis, based on 10 cohort studies and seven case-control studies, found that most studies indicate a protective effect of tea consumption against CVD. There appears to be a decrease in rate of cardiovascular disease (CVD) outcomes — conditions that occur as CVD progresses such as cardiac arrest, myocardial infarction (heart attack), unstable angina, congestive heart failure (CHF), and strokes — with increasing tea intake. Seven studies demonstrated that drinking three cups of tea per day reduced the incidence rate of MI by 11 percent. Peters and colleagues, who conducted this meta-analysis, were unable to summarize the effects of tea consumption on CHD and stroke due to the diverse factors associated with the two diseases (Hodgson, *et al.*, 2003; Vita, 2003; Peters, *et al.*, 2001).

• Mechanisms of Action for cardiovascular protection:

There are several proposed mechanisms for the protective effect of tea against CVD. These observed and proposed mechanisms are (Nagao, *et al.,* 2007; Cabrera, *et al.,* 2006; McKay and Blumberg, 2002; Duffy, *et al.*, 2001a; Duffy, *et al.*, 2001b):

- Prevention of LDL oxidation (*in vitro* and animal studies);
- Reverses poor arterial functioning in CHD patients;
- Increases lag time after tea consumption before LDL oxidation in humans;
- Decreases stenosis (narrowing and clogging) of arteries in adults; and
- Possible inverse relationship between tea intake and plasma total homocysteine levels

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Epidemiological Studies: Flavonol Intake & Cardiovascular Disease

Study/ Country	# Subjects/ Description	Length of Study	Findings/Observations	Reference
Zutphen Study/ Netherlands	550-800 men	10-15 year	Strong inverse relationship between flavonol intake and CHD, mortality, and stroke	Hertog, *et al.*, 1993; Keli, *et al.*, 1995
Rotterdam Study/ Netherlands	4807 Dutch men and women, aged 55 and older with no history of MI	5 1/2 year follow-up	↓ incidence of MI with daily tea intake > 375 ml; ↓ incidence of fatal MI with higher intakes of dietary flavonoids (quercetin + kaempferol + myricetin)	Geleijnse, *et al.*, 2002
Rotterdam Study/ Netherlands	3,454 men and women, aged 55 and older	2-3 years	Inverse association with tea intake and development and progression of ASHD	Geleijnse, *et al.*, 1999
Japanese Study	262 men, over age 30	11 months	Inverse association with tea intake and development of ASHD; Drinking ≥ 4 cups/day more protective than 2-3 cups/day	Sasazuki, *et al.*, 2000
Caerphilly, Wales Study	334 men, aged 45-59	14 year follow-up	No association of flavonol or tea intake with CHD; + association w/total mortality	Hertog, *et al.*, 1997
Scottish Heart Study	11,567 men and women, aged 40-59	7.7 years	Slight + association w/CHD mortality, all-cause mortality	Mink, *et al.*, 2007; Woodward and Tunstall-Pedoe, 1999

*This is a selective review of the literature.

Geleijnse JM, Launer LJ, van der Kuip DAM, *et al.* Inverse association of tea and flavonoid intakes with incident myocardial infarction: the Rotterdam Study. *Am J Clin Nutr* 75(5): 880-886, 2002.

Hertog M, Fesken E, Hollman P, *et al.*, Dietary antioxidant flavonoids and risk of coronary heart disease. The Zutphen Elderly Study. *Lancet* 342, 1993.

Hertog M, Feskens E, Krombout D. Antioxidant flavonols and coronary heart disease risk. *Lancet* 349:699, 1997.

Hertog M, Krombout D, Aravanis C, *et al.* Flavonoid intake and long-term risk of coronary heart disease and cancer in the Seven Countries Study. *Arch Intern Med* 155:381-386, 1995.

Hertog M, Sweetnam P, Fehily A, *et al.* Antioxidant flavanols and ischemic heart disease in a Welsh population of men: the Caerphilly Study. *Am J Clin Nutr* 65:1489-1494, 1997.

Keli S, Hertog M, Fesken E, *et al.* Flavonoids, antioxidant vitamins and risk of stroke. The Zutphen Study. *Arch Intern Med* 154:637-642, 1995.

Sasazuki S, Kodama H, Yoshimasu K, *et al.* Relation between green tea consumption and the severity of coronary atherosclerosis among Japanese men and women. *Ann Epidemiol* 10: 410-408, 2000.

Woodward M and Tunstall-Pedoe H. Coffee and tea consumption in the Scottish Heart Health Study follow up: conflicting relations with coronary risk factors, coronary disease, and all cause mortality. *J Epidemiol Community Health* 53:481-487, 1999.

McKay and Blumberg, 2002

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In vitro studies have found that LDL oxidation is inhibited by extracts of green and black tea; however, this effect was not observed in healthy adults or in smokers (McKay and Blumberg, 2002; Lotto and Fraga, 2000; Cherubini, *et al*., l999; Princen, *et al*., l998; van het Hof, *et al*., l997). Two studies involving healthy men reported an increase in lag time after green or black tea consumption and oxidation of LDL cholesterol. Although these studies found a delay in LDL oxidation, it is suggested that daily intake of 7 to 8 cups of tea was not sufficient to promote catechin concentrations high enough to inhibit LDL oxidation (McKay and Blumberg, 2002; Hodgson, *et al,* 2000; Miura, *et al*, 2000).

It is suggested, but not proven, that higher plasma concentrations of catechins, similar to concentrations attained in *in vitro* studies, can be achieved and maintained by repeated intake of tea over time, for example, one cup of tea every two hours. The effect of tea drinking may vary due to individual differences in colonic microflora and genetic differences in enzymes involved in polyphenol metabolism (Hodgson, *et al.,* 2003; McKay and Blumberg, 2002).

Endothelial dysfunction, particularly endothelium-derived nitric oxide activity, contributes to the development and progression of atherosclerosis. Normal endothelial function includes regulating vasomotor tone, platelet activity, leukocyte adhesion, vascular smooth muscle proliferation via the release of nitric oxide (NO) and other hormone-like substances (Duffy, 2001a). Endothelial dysfunction is associated with increased oxidative stress and impaired blood flow through arteries.

Antioxidants have been found to reverse endothelial dysfunction. A randomized, placebo-controlled, crossover study of 50 CHD patients found that short-term (two hours after intake of 450 ml of tea) and long-term (after daily intake of 900 ml for four weeks) reversed endothelial vasomotor dysfunction. The vasomotor function of the brachial artery was examined with vascular ultrasound at the beginning of the study and after each intervention. Tea intake improved endothelium-dependent flow-mediated dilation to the brachial artery, but had no effect on endothelium-independent nitroglycerin-induced dilation. Plasma flavonoids were increased after short- and long-term intake of tea. Water was used as the placebo and had no effect on endothelium function (Duffy, *et al*, 2001a).

A review of epidemiology studies by Vita (2003) found that tea appears to have cardiovascular benefits, but a direct cause and effect relationship can not be assumed. Vita concluded that drinking tea, a vegetable-based beverage, is in line with the American Heart Association's dietary guidelines to consume more fruits and vegetables.

Elevated plasma total homocysteine is considered an independent risk factor for atherosclerosis and CVD. Vitamins B_6, B_{12}, and folate have been found to lower plasma total homocysteine levels. It has been implicated that tea may exert a beneficial effect on homocysteine levels, but initial findings are inconclusive (Hodgson, *et al*., 2003).

Two observational studies found a strong inverse relationship between tea intake and plasma total homocysteine levels (de Bree, *et al*., 2001; Nygard, *et al*., l997). A cohort study of 1,960 adults conducted by Jacques, *et al* (2001) also reported finding an inverse relationship between tea intake and plasma total homocysteine levels after adjusting for coffee intake. This study did report a positive relationship between caffeine and plasma total homocysteine levels.

However, others have reported findings that are contradictory to the studies mentioned previously. In one small clinical study (20 subjects) daily intake of 4 gm of black tea solids, equivalent to 1 L of strong black tea, increased plasma homocysteine levels. The effect of caffeine on homocysteine levels was not evaluated in this study (Olthoff, *et al*., 2001). Another small clinical study (22 subjects) found no effect of black tea consumption on plasma homocysteine levels (Hodgson, *et al*., 2003).

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High blood pressure can accelerate the progression of atherosclerosis. Although studies involving hypertensive animals and one study of black tea drinkers in Norway have reported beneficial effects of green tea polyphenols on high blood pressure, this effect has not been reported in recent studies in Japan, Australia, and the United Kingdom (McKay and Blumberg, 2002; Hara, 2001; Hodgson, *et al.,* 1999; Wakabayashi, *et al.,* 1998; Bingham, *et al.,* 1997; Stensvold, *et al.,* 1992).

A small but transient increase in blood pressure has been noted 30 min. after drinking tea, but was absent after one hour (Hodgson, *et al.*, 1999).

Tea, including black, green, and tea polyphenols, has been found to lower elevated cholesterol levels in animals (rats and hamsters) fed a diet high in fat and cholesterol (Vinson and Dabbagh, 1998; Yang and Koo, 1997; Matsumoto, *et al.*, 1998; Yang and Landau, 2000). However, the majority of epidemiological studies and clinical trials have not demonstrated a cholesterol-lowering effect of tea. Only four of 13 epidemiological studies reported an inverse relationship between tea intake and blood cholesterol levels (McKay and Blumberg, 2002; Tewari, *et al.*, 2000; Langley-Evans, 2000; Serafini, *et al.*, 1996; Vinson, *et al.*, 1995).

One clinical trial involving 240 individuals with mild hypercholesterolemia found that consumption of a theaflavin-enriched green tea extract supplement was effective in lowering baseline total cholesterol and LDL cholesterol levels and increasing HDL cholesterol (Maron, *et al.*, 2003).

Thus, the scientific evidence does support a protective effect of tea against CVD. It is interesting to note that studies conducted in Europe and Asia tend to demonstrate a more positive relationship between tea intake and cardiovascular health than US studies (Saranow, 2004). However, more research, especially clinical trials, is needed to identify and clarify the mechanisms responsible for this protection. A large scale human clinical trial has not yet been conducted (Saranow, 2004).

• **Cancer.** The findings of many animal studies demonstrate a chemopreventive effect of tea. Intake of tea as a liquid or as tea extract has been found to inhibit the development of cancers of the skin, lung, esophagus, stomach, liver, duodenum and small intestine, pancreas, colon, bladder, prostate, and mammary gland (Cabrera, *et al.,* 2006; Yang, *et al.*, 2000, 1999 and 1996; Conney, *et al.*, 1999; Dreosti, *et al.*, 1997; Katiyar and Mukhtar, 1996; Yang and Wang, 1993). However, some conflicting findings have been reported regarding the effects of tea on colon and mammary gland cancer (Sun, *et al.,* 2005; Yang, *et al.*, 2000; Weisburger, *et al.*, 1998; Rogers, *et al.*, 1998). A systematic review and meta-analysis found that green tea consumption, but not black tea consumption, might be beneficial in reducing the relative risk of stage 1 or 2 (less severe stages) breast cancer recurrence. These findings should be interpreted with caution (Seely, *et al.,* 2005).

The effects of tea drinking on human cancers are not clear and appear to vary depending on a person's genotype, type of tea consumed, whether green or black, the socioeconomic and lifestyle factors associated with tea drinkers in different countries, and by specific type of cancer (Yuan, *et al.,* 2005; Adhami, *et al.*, 2003; McKay and Blumberg, 2002).

The chart on the next page presents a summary of findings from various studies that are cited in several review articles.

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Summary: Tea and Cancer

Country/ Location	Type of Study	Type of Cancer	Findings
Shanghai	Case control	Esophageal Pancreatic Colorectal	↑ Green tea intake↓ incidence of cancer, especially in nonsmokers and those who do not drink alcohol
Japan, Northern Turkey, Central Sweden	Epidemiological	Stomach	Tea exerts a protective effect
Japan	Prospective	Stomach	No protective effect
Netherlands	Prospective cohort	Stomach, colorectal, lung, breast	Black tea had no effect on cancer risk
Japan	Clinical	All cancers	Women consuming >10 cups of tea daily have ↓ risk of all cancers; ↑ tea intake associated with ↓ risk breast cancer metastasis and recurrence
Japan and China	Population-based case control	Colorectal	Green tea has protective effect
Finland	Cohort	Colorectal	Tea intake had positive association with colon, but not rectal, cancer
Iowa, USA	Prospective cohort	Digestive tract, urinary tract	Black tea associated with ↓ risk in post-menopausal women
Zutphen, Netherlands	Case-control	Lung	Black tea had no effect on cancer risk
Uruguay	Case-control,	Bladder	Daily tea intake of 2 or more cups of tea ↓ cancer risk
Japan, America	Case-control, Population-based	Bladder	Green tea had protective effect; ↑ survival rate associated with tea drinkers
Taiwan	Case-control	Prostate	Tea intake positively associated with cancer
Canada	Case-control	Prostate	Daily tea intake >500ml ↓ cancer risk
Canada	Retrospective cohort	Breast	Tea had no effect
Netherlands, US, Italy	Prospective cohort	Breast	Tea had no effect
Japan	Clinical	Breast	Inverse relationship between green tea intake and recurrence of cancer
Arizona, USA	Clinical trials, population based case-controlled	Skin	Dietary tea intake and topical application of tea extracts or EGCG had a protective effect

*This is selected review of the literature. Studies are cited and reviewed in Yang, *et al*., 2000; Yang and Landau, 2000; McKay and Blumberg, 2002; Adhami, Ahmad and Mukhtar, 2003.

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Green tea is typically consumed more frequently in Asian countries, while black tea is more frequently consumed in European countries. A review of human studies suggests that green tea is more protective than black tea, probably due to the presence of catechins, particularly EGCG, theaflavins and caffeine (Sun, *et al.,* 2005; Yuan, *et al.,* 2005). Black tea contains catechins, but in smaller amounts. Thearubigens are the major components of black tea and their bioavailability and biological activity are unknown (McKay and Blumberg, 2002; Yang and Landau, 2000). It is important to keep in mind that typical Asian diets are high in plant foods, which contain more catechins.

Much has been written about the potential role of green tea and stomach cancer. The findings of the studies investigating the potential protective effect of green tea against stomach cancer are conflicting (McKay and Blumberg, 2002). Stomach cancer is responsible for 18 percent of all cancer deaths in Japan, which is about eight times higher than in the US. In regions of Japan where stomach cancer rates are highest, diets are high in salty foods, such as pickles and salted fish, which have been linked to tumor development. Thus, the findings regarding green tea and stomach cancer in Japan are confounded by dietary factors (Barclay, 2001; www.msnbc.com, 2/28/2001).

No firm conclusions regarding the chemopreventive effects of tea can be made at this time (Cabrera, *et al.,* 2006). Tea drinking is associated with different life styles in different regions or countries. The inconclusive findings regarding tea and cancer may be due to different etiological factors present in different populations (Yang and Landau, 2000). The discrepancies between animal and human clinical studies may be explained by the reasons listed in the chart below.

Reasons for Conflicting Studies Re: Tea & Cancer

- Lifestyle factors, such as diet and exercise, of certain populations may mask chemopreventive effects of tea
- Environmental factors in different geographic areas may affect chemopreventive properties of tea
- Amount of tea consumed by people is lower than concentrations given to animals
- Tea may inhibit carcinogenesis in animals via mechanisms not applicable to humans

Yang *et al.*, 2000; Adhami, Ahmad and Mukhtar, 2003.

Although no clear conclusions can be drawn from various epidemiological studies, studies with human cancer cell lines demonstrate that green and black tea polyphenols can inhibit their growth. Green tea appears to be slightly more effective in inhibiting cancer development. EGCG, found in green tea, appears to be the most efficient inhibitor of most cancer cell lines.

The concentrations of tea polyphenols required to inhibit cell growth was about one to two orders of magnitude higher than peak concentrations seen in humans. Tea polyphenols appear to inhibit cancer development by several different mechanisms, which include induction of apoptosis, reduction of production of prostaglandin E2 (PGE2), entrapment or quenching of activated carcinogen, inhibition of enzymes involved in tumor promotion, and inhibition of growth-related signal transduction pathways (Yang, *et al.*, 2000).

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The chart below is a list of some of the proposed mechanisms for the chemopreventive effects of tea.

Proposed Mechanisms - Chemopreventive Effects of Tea

- Antioxidant and ROS scavenging activity
- Inhibit biochemical markers of tumor initiation
- Inhibit biochemical markers of tumor promotion
- Promote apoptosis or programmed cell death
- Effect on detoxification enzymes
- Protection against mutagenicity and genotoxicity
- Trapping of activated metabolites of carcinogens

Mukhtar and Ahmad, 2000; Yang *et al.*, 2000; Yang, Maliakal, Meng, 2002.

A recent randomized, controlled study involving 143 heavy smokers found that daily consumption of decaffeinated green tea (4 cups) resulted in a 31 percent reduction of levels of 8-OHdG, an indicator of oxidative DNA damage. Oxidative DNA damage is a contributing factor to the development of cancer, as well as cardiovascular disease. Smokers typically have high levels of oxidative DNA damage and changes in these levels are easily detected. This 4-month study divided subjects into three groups, decaffeinated green tea drinkers, decaffeinated black tea drinkers, and water drinkers. Only the green tea group experienced a reduction 8-OHdG levels (Hakin *et al.*, 2003).

Mucosa leukoplakia is a pre-cancerous oral condition characterized by an oral lesion. In a double-blind, placebo-controlled trial of 59 patients administration orally and topically of a black and green tea mixture resulted in partial regression of the lesion in almost 38 percent of treated patients (Li, *et al.*, 1999). This study raises the possibility of using green and/or black tea, particularly tea polyphenols, in the treatment of oral cancer. Much more research is needed.

• **Dental caries.** Compounds in tea may play a role in the prevention of plaque build-up on teeth and dental caries, as tea drinking was associated with lower levels of dental caries in a cross-sectional study of over 6,000 secondary school children in England (Jones, *et al.*, l999).

Two factors may play a role in this possible health benefit. First, tea contains natural fluoride. Second, tea extracts have been found to inhibit the potential cariogenicity of oral bacteria such as *Escherichia coli, Streptococcus salivarius,* and *Streptococcus mutans* (McKay and Blumberg, 2002; Rasheed and Haider, l998).

• **Bone health.** Two separate studies have demonstrated that tea drinking is associated with greater bone mineral density. The findings of the Mediterranean Osteoporosis Study indicate that tea consumption is an independent factor that protects against the risk of hip fractures in men and women over the age of 50 (McKay and Blumberg, 2002; Kanis, *et al.*, 1999; Johnell, *et al.*, l995). A large British study of more than 1,200 women, aged 65 to 76 years, found that women who drank tea had greater bone mineral density than women who did not (Hegarty, *et al.*, 2000).

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• **Kidney stones.** Contrary to the findings of from some studies, tea consumption may protect, not contribute to, the development of kidney stones as indicated by a large prospective cohort study. It has been suggested that tea affects the absorption of oxalates resulting in kidney stone formation (Massey, 2000). In the Nurses' Health Study, a prospective cohort study of more than 81,000 women, aged 40 to 65 years, tea drinking was inversely associated with kidney stone development (Curhan, *et al.*, l998).

• **Possible anti-diabetic effects:** Findings of a recent study involving diabetic rats demonstrated that daily intake of black or green tea for three months inhibited diabetic cataracts. In addition, the teas had a blood glucose lowering effect. The dosage of tea administered to the rats is equivalent to a 143 lb person drinking $4^1/_2$ cups (8 oz/cup) of tea daily. Human studies are needed before we can make evidence-based recommendations regarding the anti-diabetic effects of tea. The researchers write: "Teas may be a simple, inexpensive means of preventing or retarding human diabetes and the ensuing complications" (Vinson and Zhang, 2005).

• **Weight control.** Can green tea "melt away" body fat? That is a claim that is implied in one company's marketing campaign for their carbonated green tea beverage enhanced with EGCG and caffeine. Enviga™, a carbonated green tea beverage, was introduced in January 2007 by Beverage Partners Worldwide (BPW), as a joint venture of Nestle S. A. and the Coca Cola Company. What sets Envita™ apart from other green teas is the claim that it combines great taste and "*negative* calories." According to marketing claims, Enviga™ contains the optimum blend of green tea extracts (EGCG), caffeine, and phytochemicals, which work with the body to speed up metabolism and increase energy use, resulting in a negative caloric effect (Tappy, 2004; Wasserman, 2007).

Dietitians' ears perked up at that one! These claims have not gone unchallenged. According to the Center for Science in the Public Interest (CSPI), many of Enviga's claims are based on a 72-hour Nestle-funded study of 31 healthy lean people, who were given a drink containing amounts of EGCG and caffeine equivalent to three cans of Enviga. According to a news release by Coca Cola, subjects experienced an average increase in calorie burning by 60 to 100 kcal. However, long-term testing is needed and it is important to note that the Nestle-funded study involved lean to normal-weight subjects. The CSPI has taken the stance that the marketing claims regarding Enviga™ are irresponsible and misleading, if not fraudulent. To date the scientific evidence is inconclusive (Ota, *et al.,* 2005; Tappy, 2004; Komastu, *et al.,* 2003; Rumpler, 2001; Dullo, *et al.*, 2000 and 1999).

Animal and two clinical studies suggest that green tea polyphenols stimulate brown fat thermogenesis (Nagao, *et al.*, 2005; St-Onge, 2005; Dullo, *et al.*, 2000 and 1999; Han, *et al.*, l999). Brown fat is a thermogenic or heat-producing type of adipose tissue that contains a dark pigment that is present at birth in many mammals, including man. Stimulating thermogenesis results in increased energy production and an increase in calories expended.

Thermogenesis and fat oxidation are under the control of the sympathetic nervous system and its neurotransmitter norepinephrine. A clinical study found that intake of green tea extract (containing 90 mg EGCG and 50 mg caffeine) by 10 healthy men resulted in a significant increase (4 percent) in 24-hour energy expenditure, a decrease in respiratory quotient, and an increase in urinary excretion of norepinephrine. On two different occasions the subjects in this study were also given a placebo and caffeine. Neither caffeine nor the placebo had an effect on expenditure and norepinephrine (Dullo, *et al.*,

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l999). The findings of this study suggest that green tea polyphenols may play a role in weight control and may be beneficial in treating obesity.

Several years ago one dietary supplement company decided to "bank" on EGCG as a weight loss phytochemical. The One-A-Day Weight Smart Dietary Supplement,™ a multivitamin and mineral supplement containing EGCG (27 mg), as well as chromium, selenium, and caffeine, was introduced.

This supplement is marketed to women. Advertising proclaims that this product will enhance metabolism and convert food to fuel. While many testimonials support this product, many people reported nausea and vomiting after taking it, even if taken with food, while others reported sleep problems (www.drugstore.com, Accessed 2/14/2004). Since the introduction of One-A-Day Weight Smart, countless generic versions, as well as over-the-counter diet pills containing EGCG, have emerged on store shelves and are available on the internet.

• **Anti-inflammatory effect/arthritis.** An animal study that involved collagen-induced arthritic mice found that green tea polyphenols significantly reduced the risk and severity of arthritis. In this study the expression of inflammatory mediators in arthritic joints was lower in the mice fed green tea (Haqqi, 1999). This study may stimulate interest in conducting human studies to investigate the role of tea in preventing and treating arthritis.

• **Immune function.** Green tea appears to enhance immune function by stimulating the production of several immune cells. Tea polyphenols are able to neutralize germs including those that cause diarrhea, pneumonia, cystitis, and skin infections. In addition, tea extracts have topical antibacterial properties (Carper, 2001; Bukowski, l999; Hamilton-Miller, l995).

HIV Protection: In the future EGCG may play an important role in the development of new HIV drug therapies that would protect against HIV and prevent the progression of HIV. An in vitro study conducted in Japan found that EGCG blocks the binding of the HIV virus to human CD4 molecules and T-cells, vital immune cells. It should be noted that the concentrations of EGCG used in this study were many times over the blood concentration that could be achieved by drinking green tea. To achieve these concentrations it would be necessary to take therapeutic doses of EGCG (Kawai, 2003). Researchers at Baylor College of Medicine are conducting more investigations into the potential therapeutic role of EGCG (Nance and Shearer, 2003).

• **Possible probiotic effect.** Kombucha tea, made by placing a kombucha "mushroom" (actually a symbiotic colony of bacteria and yeasts) in sweetened black tea, is considered a traditional medicinal food. This tea is thought to have originated centuries ago in the far East, but over time it made its way to Russia and Europe. The bacteria and yeast of the mushroom cause the tea to ferment. Kombucha tea is an acidic, sharp-tasting beverage that tastes best after being refrigerated. The kombucha mushroom can duplicate itself during fermentation. This second mushroom can be split off and used to produce another brew of tea. Kombucha tea is now available in the refrigerated section of selected US grocery stores such as Whole Foods.

Two studies investigated the effects of administering green tea flavonoids in capsules to elderly Japanese nursing home patients. One study involved patients with feeding tubes, while the second study involved bedridden patients that did not have feeding tubes. In both studies, green tea flavonoids

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altered colonic bacteria to favor "friendly" bacteria and reduced fecal odor (Goto, *et al*. l998; 1999). More studies are needed to clarify the possible probiotic effect of tea.

Although there are no scientific studies to support the possible benefits of this tea, there is a wealth of anecdotal information. Most of the proposed benefits of kombucha tea are related to improved functioning of the digestive system (www.medicinalfoodnews.com, accessed 7/2001).

Dietary Recommendations

It has been suggested that a person should drink three to six 8-oz cups of tea per day, but not exceed 10 cups per day. John Weisburger of the Institute for Cancer Prevention recommends drinking 6 to 10 cups daily as this is the amount demonstrated effective in improving health in population studies. However, not all experts agree on what should be recommended regarding tea intake. However, many other studies conducted on the health benefits of tea are based on an intake of three cups of tea. Howard Sesso, researcher at Harvard School of Public Health, warns it is too premature to make specific recommendations regarding tea intake (Saranow, 2004). In Asian countries a typical daily intake of green tea is about three cups, which provides 240 to 320 mg of polyphenols. The tea can be green or black, iced or hot, decaffeinated or with caffeine. Bottled teas are *not* good sources of polyphenols. Children should not be given too much tea as it chelates (binds) iron.

If you are not a tea drinker, it is possible to take tablets or capsules containing standardized extracts of tea polyphenols, particularly EGCG. These dietary supplements can provide up to 97 percent polyphenol content or the equivalency of drinking four cups of tea. Decaffeinated tea polyphenol dietary supplements are available.

A word of caution: The following types of medications may have adverse interactions with green tea: adenosine (a medication given in a hospital setting for an irregular and unstable heart rhythm); certain antibiotics; benzodiazepines (medications used to treat anxiety); beta-blockers (propanolol and metoprolol); blood-thinning drugs like warfarin; chemotherapy medications; clozapine (an antipsychotic drug); ephedrine; lithium (used to treat manic depression); monoamine oxidase inhibitors (MAOI), which are used to treat depression; oral contraceptives; and phenylpropanolamine, which is an ingredient in over-the-counter cough and cold medications and weight loss products (Website: www.healthandage.com, Date accessed: 11/30/02). In addition, the effect or interactions of green tea consumption and conventional cancer treatment, such as chemotherapy or hormonal therapy have not been fully defined. Thus, caution should be exercised regarding intake of green tea while undergoing conventional cancer treatment (Seely, *et al.,* 2005).

Fads come and go. The green tea phenomenon shows no sign of abating. That may be the most dangerous time, as clever marketers and sincere but misinformed advocates begin to believe their own propaganda. With other substances, we've seen great damage done by two kinds of practitioners — those who know nothing, and those who know a little, but think they know a lot. Right now, we're all in the second category — what we know for sure is that the research regarding the health benefits of tea drinking, particularly green tea, looks promising. But the evidence is not yet conclusive (Cabrera, *et al.*, 2006).

The good news is, there appears to be no reason *not* to drink tea in moderation — and it may even prove to be very good for you!

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Exam Questions for GRT09

1. The tea primarily consumed in Asian countries is:
    a. green tea
    b. black tea
    c. oolong tea
    d. herbal tea
    e. orange tea

2. _____ is made from freshly harvested leaves.
    a. green tea
    b. kombucha tea
    c. black tea
    d. oolong tea
    e. herbal tea

3. The majority of tea produced worldwide is:
    a. green tea
    b. black tea
    c. oolong tea
    d. herbal tea
    e. kombucha tea

4. The most abundant dietary polyphenols are:
    a. phenolic acids
    b. lignans
    c. flavonoids
    d. stilbenes
    e. isoflavones

5. People who consume a lot of coffee have a high dietary intake of _____.
    a. flavonoids
    b. phenolic acids
    c. anthocyannis
    d. stilbenes
    e. isoflavones

6. People who frequently consume fruits, red wine, chocolate, and tea will have a high dietary intake of:
    a. isoflavones
    b. phenolic acids
    c. flavonoids
    d. lignans
    e. phenylalanine

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7. Polyphenols are:
    a. strong antioxidants
    b. found abundantly in a variety of plants
    c. are diverse in their chemical structures
    d. probably well absorbed by the body
    e. all of the above

8. _____ tea contains the highest concentration of flavonoids.
    a. Brewed
    b. Instant
    c. Decaffeinated
    d. Bottled
    e. Herbal

9. _____ are the flavonoids found in apples, pears, grapes, red wine, and tea and are responsible for the astringent taste of these foods.
    a. flavones
    b. flavonols
    c. quercetin
    d. proanthocyanidins
    e. anthocyanins

10. The catechins in black tea are:
    a. epicatechin (EC) and epigallocatechin-3-gallate (EGCG)
    b. epigallocatechin-3-gallate (EGCG) and thearubigin
    c. thearubigins and epicatechin (EC)
    d. theaflavins and thearubigins
    e. thearubigins and epicatechin

11. Thearubigins represent about _____ percent of the solids in brewed black tea.
    a. 5
    b. 10
    c. 20
    d. 30
    e. 35

12. Polyphenols prevent peroxidation reactions because they:
    a. bind with iron
    b. bind with copper
    c. bind with nitrogen
    d. bind fatty acids
    e. all of the above

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13. Tea drinking may decrease the absorption of:
    a. calcium
    b. fat-soluble vitamins
    c. water-soluble vitamins
    d. heme iron
    e. nonheme iron

14. Animal studies indicate that:
    a. EGCG in green tea may inhibit growth of cancer cells
    b. black tea is slightly more effective in inhibiting tumor development
    c. theaflavins are the most efficient inhibitor of cancer cell growth
    d. one to two cups of tea daily is adequate to protect against cancer development
    e. all of the above

15. Most studies conclude that tea drinking :
    a. protects against cardiovascular disease
    b. decreases incidence of heart attacks
    c. is positively associated with total mortality
    d. decrease stenosis of arteries
    e. all of the above

16. Extracts from green and black tea may:
    a. increase LDL oxidation
    b. increase HDL levels
    c. reverse endothelial dysfunction
    d. decrease triglyceride levels
    e. improve insulin resistance

17. Tea may be beneficial to dental health:
    a. by preventing plaque build-up
    b. because it contains fluoride
    c. inhibiting the cariogenicity of oral bacteria
    d. all the above
    e. a and c only

18. Two studies indicate tea drinking is associated with:
    a. greater bone density in young men only (aged 30-40)
    b. greater bone density in young men and women (aged 30-40)
    c. greater bone density in older men and women (over age 50)
    d. decreased bone density in women (over age 50)
    e. decreased bone density in men (over age 50)

19. A large cohort study indicates that tea drinking may:
    a. be positively associated with kidney stone formation
    b. be inversely associated with kidney stone formation
    c. have no effect on kidney stone formation
    d. decrease incidence of urinary tract infections
    e. increase incidence of urinary tract infections

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20. The component of green tea associated with thermogenesis is:
    a. thearubigins
    b. theaflavins
    c. epigallocatechin-3-gallate (EGCG)
    d. Phenolic acids
    e. Caffeine

21. Polyphenols in green tea may aid in weight loss by:
    a. increasing 24-hour energy expenditure
    b. decreasing thermogenesis
    c. increase respiratory quotient
    d. decreasing appetite
    e. increasing lipolysis

22. Health professionals should:
    a. recommend that tea intake not exceed 12 cups per day
    b. advise that between 3 to 10 cups of tea daily may provide some health benefits
    c. advise clients or patient about possible adverse drug interactions and green tea
    d. all the above
    e. b and c only

23. Kombucha tea is a:
    a. mixture of green tea and honey
    b. mixture of green and black tea
    c. a herbal tea that enhances metabolism
    d. probiotic tea made from a "mushroom"
    e. sweet tasting tea made from wild flowers

24. In the future EGCG may prove to be beneficial in
    a. developing new HIV drug therapies
    b. increasing thermogenesis
    c. inhibiting cancer growth and development
    d. protecting against heart attacks
    e. all of the above

25. An initial laboratory study found that:
    a. thearubigins in black tea can attack and destroy the HIV virus
    b. EGCG in green tea can attack and destroy the HIV virus
    c. EGCG in green tea can prevent the HIV virus from attaching to T cells
    d. drinking 4 cups of green tea daily may protect against HIV infection
    e. thearubigins may serve as a model for future HIV drug therapies

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