**Classification of Secondary Metabolites: How Plants and Humans Use Them**

Plants produce a variety of compounds that can be divided into primary metabolites and secondary metabolites. Primary metabolites are essential for the survival of the plant and include sugars, proteins and amino acids.

Secondary metabolites were once believed to be waste products. They are not essential to the plant’s survival, but the plant does suffer without them. Secondary metabolites also have many uses for us, too. Some are beneficial, and others can be toxic.

**Alkaloids**

Alkaloids are secondary metabolites. They are primarily composed of nitrogen and are widely used in medicine. They can also be highly toxic.

**Morphine** was the first alkaloid to be found. Morphine comes from the plant *Papaver sonniferum*, or the opium poppy. It is used as a pain reliever in patients with severe pain levels and cough suppressant.

Another example of an alkaloid is **cocaine**. It can be highly dangerous and addictive. However, it has also been used as an anesthetic. Cocaine has long been used by the people of South America to alleviate hunger. Workers chew on the leaves while working, which is not dangerous because the leaves only contain a small amount of cocaine. However, cocaine derivatives are very dangerous when habitually used and can be deadly.

Perhaps the most loved and known alkaloid is **caffeine**. While we use it to stay alert, it has protective properties for the plants it comes from: cocoa, coffee and tea.

Seedlings of the coffee plant have a high concentration of caffeine. The high concentration is toxic and protects the seedlings from insects that want to snack on it.

Toxic caffeine levels also have another interesting defense mechanism. It prevents the germination of any other plants in the area. This is referred to as **allelopathy**. In humans, caffeine has also been thought to reduce the risk of diabetes and heart disease in addition to helping us face long days of work and school.

**Terpenoids**

**Terpenoids** are made of isoprene units and are found in all plants. They are the largest group of secondary metabolites and are very volatile, which means they evaporate easily.

Isoprene is a gas produced in the chloroplasts and released by the leaves. Isoprene is thought to protect the plant from heat.

**Essential oils** give plants their fragrance. In some plants, the scent is used to deter herbivores and protect the plant from dangerous pathogens. We use essential oils for aromatherapy and medicine. In aromatherapy, essential oils are thought to improve the mood and mental functioning. In alternative medicine, essential oils are thought to have quite a few benefits.

Most of the time, essential oils are dangerous if consumed so they are usually applied topically or inhaled. They can be used for skin issues, respiratory ailments and as antiseptics.

Next is **taxol**, which has become important in the medical field. It is used to treat ovarian and breast cancer. Taxol comes from the bark of the Pacific yew tree. The bark produced very small amounts of taxol and the process killed the tree. Other sources needed to be found.

Now, other sources of taxol include a fungus that grows on the tree and needles of the European yew.

The final type of terpenoid is the one that is the most familiar to us: **rubber**. It is the largest of the terpenoids because it contains over 400 isoprene units. Rubber is obtained from**latex**, which is a fluid produced by *Hevea brasilenis*. The uses for rubber are numerous and go back hundreds of years. Today, we use rubber in shoes, erasers, tires, gloves, spandex and the beloved rubber ducky.

**Phenols**

The final type of secondary metabolites has recently become very popular due to their health benefits: the **phenols**.

The phenols consist of a **hydroxyl group** (–OH) attached to an aromatic ring. Phenols are found in nearly all parts of the plant and in nearly every plant on the planet.

The first group of phenols is the**flavonoids**. Flavonoids are water-soluble pigments found in the vacuoles of plant cells. Flavonoids can be further divided into three groups: anthocyanins, flavones and flavnols.

**Anthocyanins** range in color from red to blue and purple. The color depends on the pH of the environment. Anthocyanins are most commonly found in grapes, berries and have a wide range of health benefits. Anthocyanins are believed to protect against heart disease, diabetes and even cancer when they are consumed. They are also appearing in skincare products to slow down the aging process.

The next two groups have white or yellow pigments. They are called **flavones** and **flavnols**. As a group, the phenols attract pollinators to the plants and even impact how plants act with one another.

Yet another medically relative phenol is **salicylic acid**, which is the active ingredient in aspirin. It comes from the bark of the willow tree. It has been used to effectively treat aches and fevers since the days of Hippocrates. It also has cosmetic uses.

It is used in numerous skincare products to treat acne, large pores and dermatitis.The final type of phenol is important to the structure of the plant and is called **lignin**. It adds stiffness and strength to cell walls of the plant cells. Lignin is crucial to terrestrial plants because it supports the branches and size. It also allows the cell wall to be waterproof and protects the plant from fungal attacks.

Not only do the secondary metabolites have functions for the plants, they have proven to be pretty beneficial for us, too. Their effects have not only been cultivated in recent years, but for centuries. Be sure to eat your berries for their great health benefits, and remember where the active ingredient in that aspirin you took came from.

**How are cat allergies triggered?**

Certain proteins that are naturally produced by the cat can serve as an allergy trigger in people that are sensitive to them. The allergenic compounds that trigger an adverse reaction are usually the Fel d 1 protein, which is secreted by the sebaceous glands of the skin, and the Fel d 4 protein, which is present in the cat’s saliva. Direct contact with a cat, being within a home where a cat lives or even being in an area where a cat has previously been can all trigger an allergic reaction in people who are sensitive to cats. Symptoms can range from hay fever-like symptoms including sneezing, itchy eyes and a sore throat, up to coughing, wheezing and asthma attacks in more severe cases.

It is often assumed that it is cat fur or cat dander that causes an allergic reaction, but this is not entirely accurate. When a cat moults or sheds fur, this fur distributes the allergenic compounds present on the hair around the house, meaning that cats that shed a lot may cause more of a reaction than cats that do not; but the fur in and of itself is not the cause of the allergy trigger.

Being around a cat or in a home where a cat resides can be very uncomfortable for sufferers of cat allergies!

**Cat’s Urine**

Researchers have uncovered the molecular pathway whereby cats produce the species-, sex- and age-specific compounds with which they mark their territories (Fig. 1). Cats may also use the same substances to identify each other and attract mates.

The work provides significant new information on chemical communication in mammals, and may lead to a practical way of neutralizing the odor of cat urine in domestic environments.

Previous studies showed that felinine, an odorless compound thought to be the precursor of cat pheromones, is present in cat urine. It was believed that felinine was produced from the 3-methylbutanol-glutathione (3-MBG) present in cat’s blood, but the reaction pathway was unknown.

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Cauxin, a member of a group of enzymes that breaks chemical bonds in a variety of organic compounds, is produced only in the kidney of the domestic cat and closely-related species of the cat family.

In the laboratory, the team found that cauxin split 3-methylbutanol-cysteinylglycine (3-MBCG), converted from 3-MBG by an enzyme, into felinine and glycine. The researchers then monitored the levels of cauxin and felinine in the urine of male and female cats over time, and discovered that the two compounds tended to increase in step with each other in cats older than three months. Neither was present in cats younger than two and a half months.

Although felinine is odorless, it develops a smell similar to cat urine when stored at room temperature. When the researchers analyzed volatile compounds from the air above cat urine, they found natural breakdown products of felinine which produced the characteristic odor. These volatile compounds, which vary according to age and sex, may well be the active ingredients in cat chemical communication, the researchers speculate.

Based on this work, the team has suggested ways of eliminating cat odor. One possibility is to block felinine production by adding a cauxin inhibitor to cat food. This would be difficult, says team member Masao Miyazaki. An easier alternative, he says, may be to use compounds containing metal ions, such as gold, silver and copper, which bind to and neutralize felinine derivatives carrying the pungent thiol group.