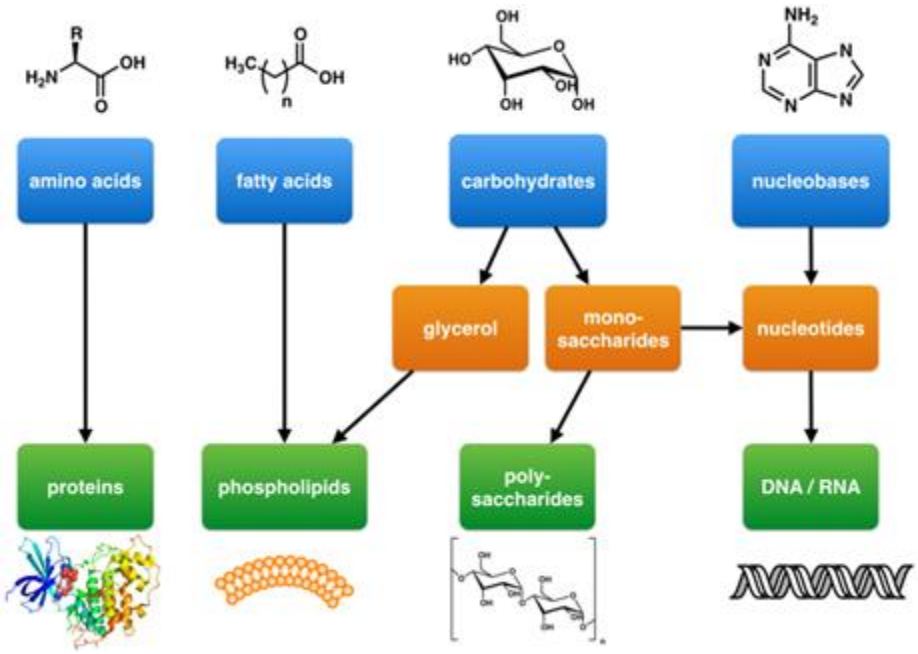
Natural Products Testing

Analytical Background:

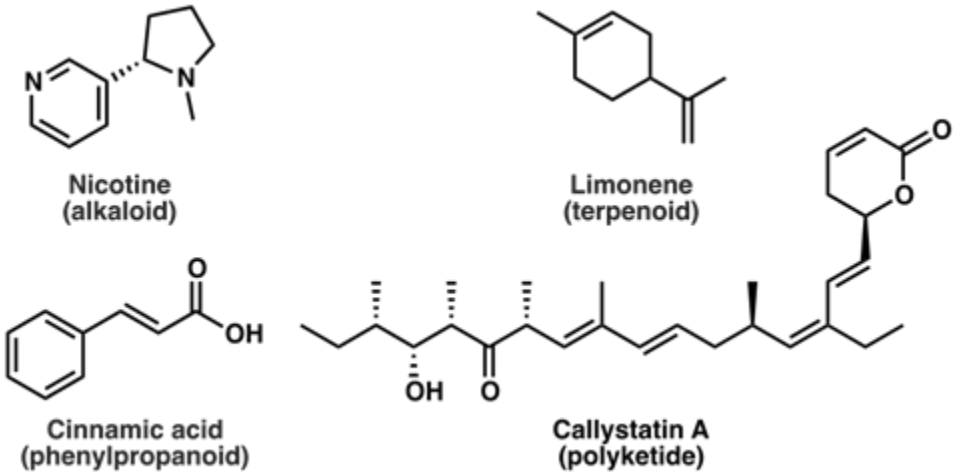
Natural Products

In the broadest sense, a **natural product** is a chemical compound produced in nature by a living organism. Within the field of **organic chemistry**, the term natural product is usually restricted to purified organic compounds produced by primary or secondary **metabolic pathways** and isolated from natural sources. However, some of these natural compounds can be synthesized in laboratory settings. Since these **synthetic** "natural" compounds can typically be manufactured in greater abundance and less expensively than true natural compounds can be extracted and purified, manufactures of food, beverage and pharmaceutical products often substitute these synthetic compounds for organic ones. As such, it is important to confirm the authenticity of commercial consumer products and products labeled as 'all natural'.

There are two basic classes of natural products: primary and secondary **metabolites**. **Primary metabolites** are small molecules or compounds that are directly involved in the normal/natural growth, development and reproduction of an organism. These metabolites perform an **intrinsic**, **physiological** function in the organism and are associated with essential cellular processes, such as nutrient assimilation and energy production. As such, these natural products often have a wide distribution across **species**, **phyla** and **kingdom**. Primary metabolites are often referred to as the building blocks of life and include carbohydrates, lipids, amino acids and nucleic acids.



Secondary metabolites are small molecules or compounds that are not essential for survival of the organism. These metabolites have a broad range of functions, many of which are unknown, and tend to have a restricted distribution across species. For example, functions of these metabolites include **pheromones**, molecules responsible for social signaling within a species, and allelochemicals, molecules used as weapons to repel or poison competitors, prey and predators. The general structure classes of secondary metabolites include **alkaloids**, **phenylpropanoids**, **polyketides**, and **terpenoids**.



Both primary and secondary natural products can be extracted from the cells, tissues and **secretions** of organisms, from microorganisms to complex plants and animals. These **crude** or **unfractionated** extractions contain a mixture of structurally diverse chemical compounds from which the product of interest must be **isolated** and **purified**. The ease or even ability of a natural product to be isolated and purified depends upon its structure, **stability** and abundance in the crude extract. For example, benzylpenicillin or penicillin G, a natural product of the penicillium genus of fungi, was identified as an **antibiotic** in the late 1920s and by the 1930s it was being isolated and used medicinally. However, the structure of penicillin G was too fragile to be isolated and stabilized. Developments in small molecule X-ray crystallography led to its structural determination, facilitating the isolation and synthesis of penicillin G in commercial quantities.

Ideally, the crude extract is refined so that a single compound is present in the purified product. Since each natural product has a unique chemical structure, structure determination is used to identify and authenticate commercial natural products.

Authenticity and Adulteration

Sometimes manufactures of food and beverage products substitute synthetic or **exogenous** natural products for intrinsic or **endogenous** natural products. These **adulterated** substances are often manufactured to save the manufacturer money by replacing the more valuable or expensive endogenic natural product with a less valuable exogenic one. Two common examples are the addition of beet sugar to honey and olive oil refined with a high oleic acid oil, such as sunflower oil or canola oil. Sometimes, the commercial substance is adulterated with a natural product of a different geographic or biological origin, such as a single flower honey or

Spanish olive oil containing natural product from other regions or species.

Another way natural products can be adulterated in through manipulating the bioprocesses responsible for the production of primary and secondary metabolites. Wine, for example, can be adulterated through the addition of exogenous sugar during fermentation in order to increase its ethanol content and, thus, the alcohol grade of the wine. Similarly, livestock farmers use dicyandiamide fertilizers (DCD) on soils where cows graze to reduce the natural conversion of ammonia in urine to nitrate and nitrous oxide, which slows down nitrogen leaching in pastures. The increased nitrogen reservoir leads to an apparent increase in the protein content of milk produced by livestock grazing on DCD treated pastures. DCD is harmful to humans and so this adulteration is not only tampering with natural production of milk proteins, it is potentially introducing a toxin into the product.

Authenticity testing of natural products uses the structure of natural compounds to identify and differentiate between them, revealing adulterated and mislabeled commercial products.