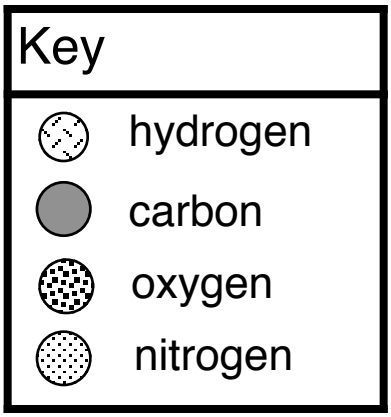
Chapter 9: Organics Containing Nitrogen

Organic Functional Groups

(containing nitrogen)

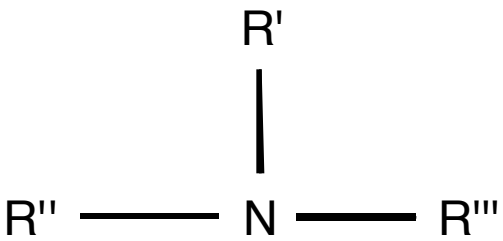


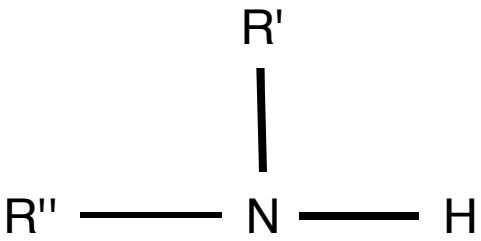
Amines:

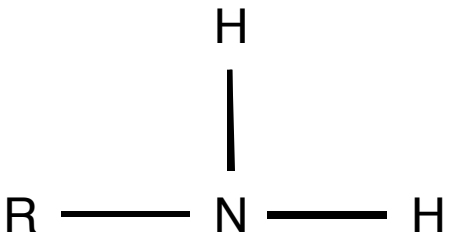
Amines are compounds in which a nitrogen atom is bonded to a total of three substituents:

A) one or more carbon skeletons
B) the remainder H atoms

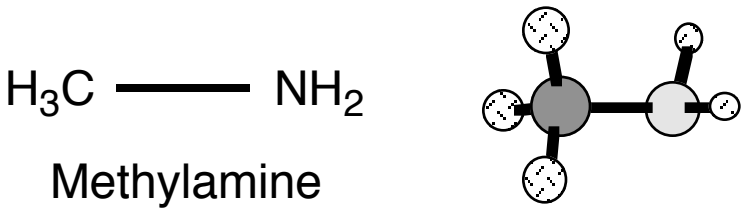
The generic formulas for amines, then, would appear as follows:

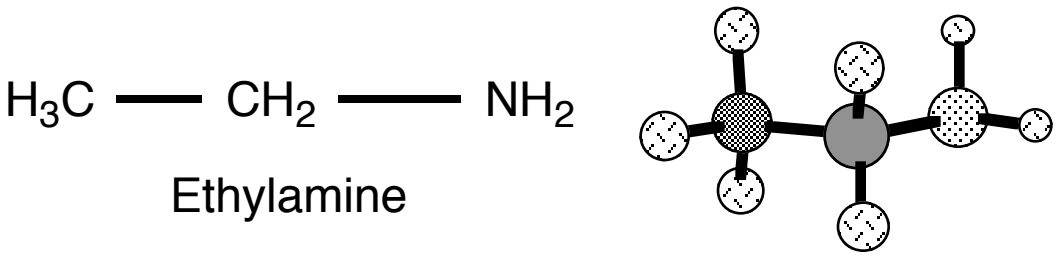


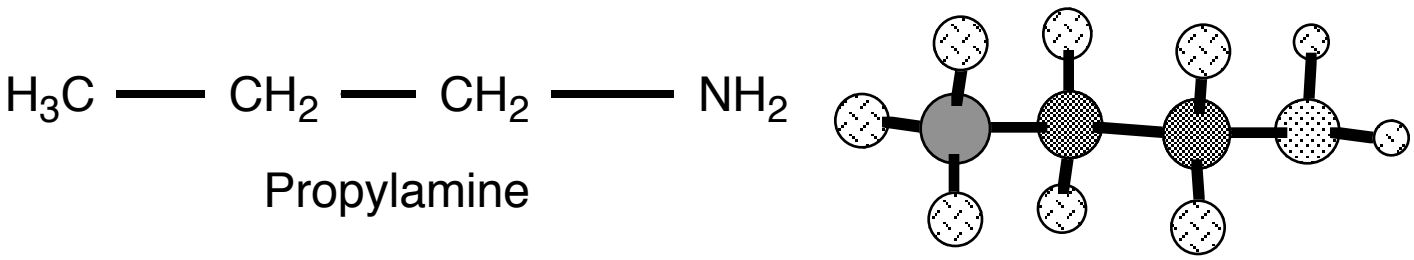




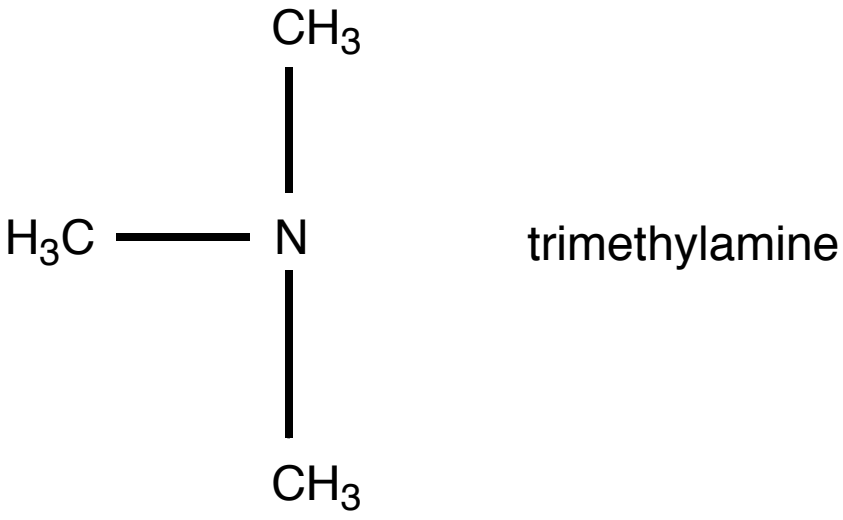
The amine with 3 R groups is sometimes called a tertiary amine. The amine with 2 R groups is called a secondary amine. The amine with one R group is called a primary amine. Amines superficially resemble ammonia, and, as you might expect, are basic as a result.
Examples of some simple amines:





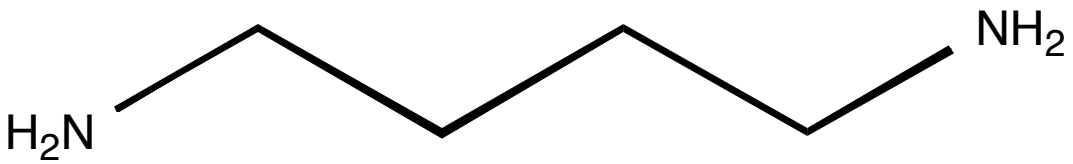


Amines are noted for their foul smell, one that often causes a feeling of nausea. An example is the tertiary amine, trimethyl amine (TMA), which is the compound emitted by rotting fish:

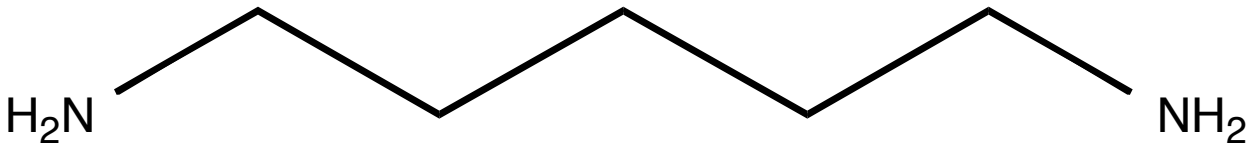


trimethylamine

Rotting meat and human flesh produce two noisome compounds which, perhaps, are nature's way of preventing us from consuming poisonous food:



putrescine



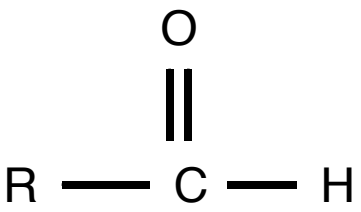
cadaverine

The offensiveness and occurrence of these compounds is amply communicated by their names.

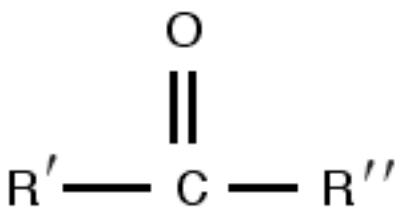
Amides

We have encountered the carbonyl group earlier in our study of aldehydes and ketones. Imagine a ketone in which we replaced a carbon skeleton with an amine ($-NH_2$). The we would have an amide. The generic formulas for aldehydes and ketones will be reproduced below, so that you can compare them to that of an amide, and form your own judgment about the relatedness of these compounds:

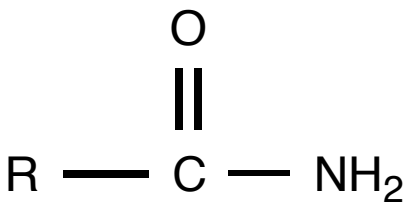
An Aldehyde



A Ketone

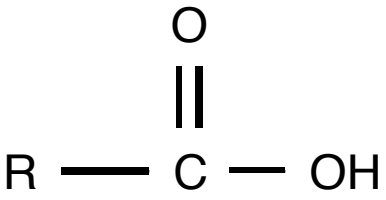


An Amide

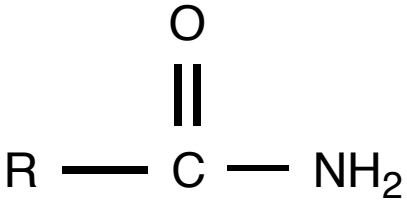


Another way of viewing this is that an amide is a carboxylic acid in which the –OH group has been replaced by an $-NH_2$ group. We place the generic formulas of a carboxylic acid and an amide side-by-side below to let you examine the logic of this comparison:

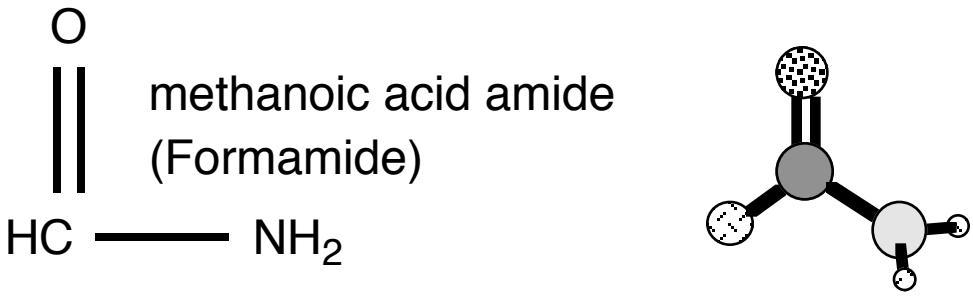
A Carboxylic Acid

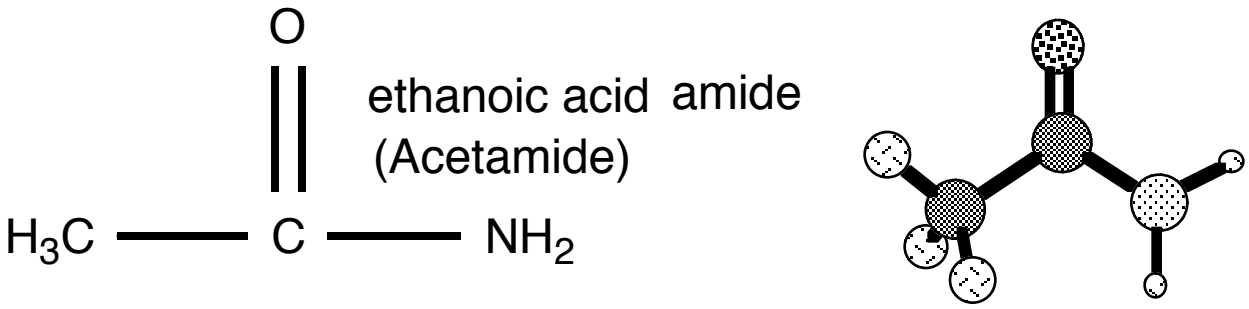


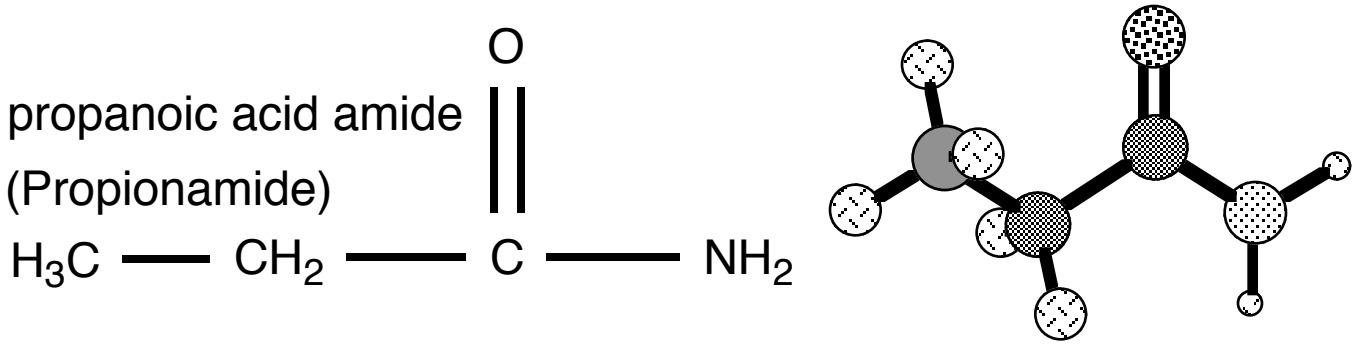
An Amide



Here are a couple of simple amides. You can see that the systematic naming is pretty straightforward. You have to think of which acid the amide is similar to, and then just append the word "amide" to the acid name. The old naming (in the parentheses) used the now trivial acid names as the root for the name of the amide:





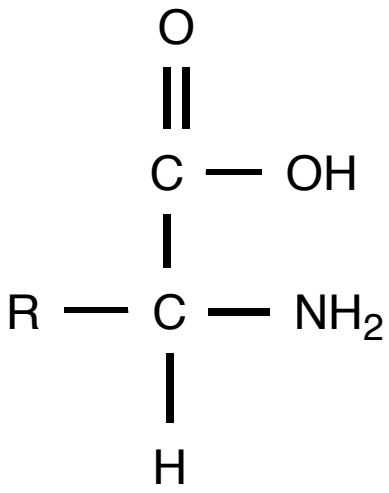


It turns out that amides are extremely important for an understanding of human biology. We will discuss the reason for this importance after we introduce on final kind of organic molecule.

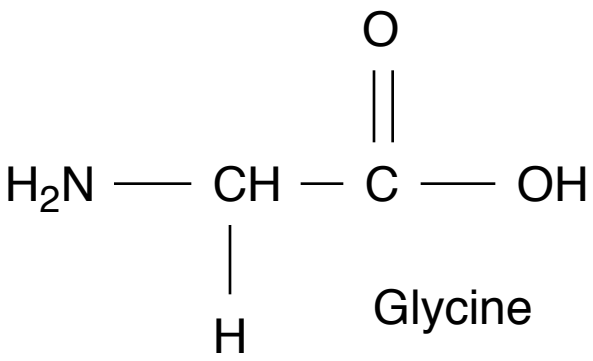
Amino Acids

We haven't spoken very much about bifunctional compounds, compounds that have more than one functional group on them, but now we have learned enough to speak about some very important ones.

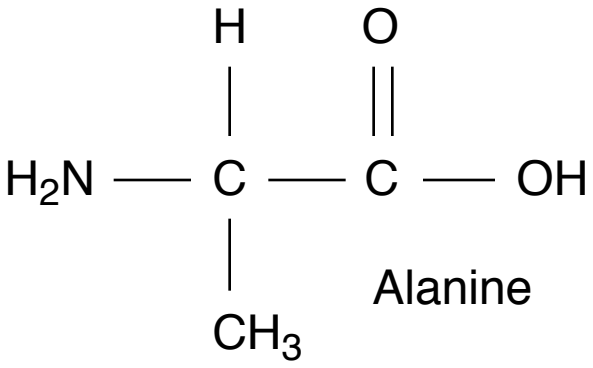
There is a class of compounds that contains an amine group, a carboxylic acid group, a hydrogen, and one of our world famous "R" groups--some undefined carbon skeleton. Members of this class of compounds are called amino acids, and they have a generic formula, as follows:



The "R" group is the only thing that differentiates one amino acid group from another and is called the **amino acid residue**. It can be an "H" atom or any carbon countering group. The two simplest amino acids are shown below:



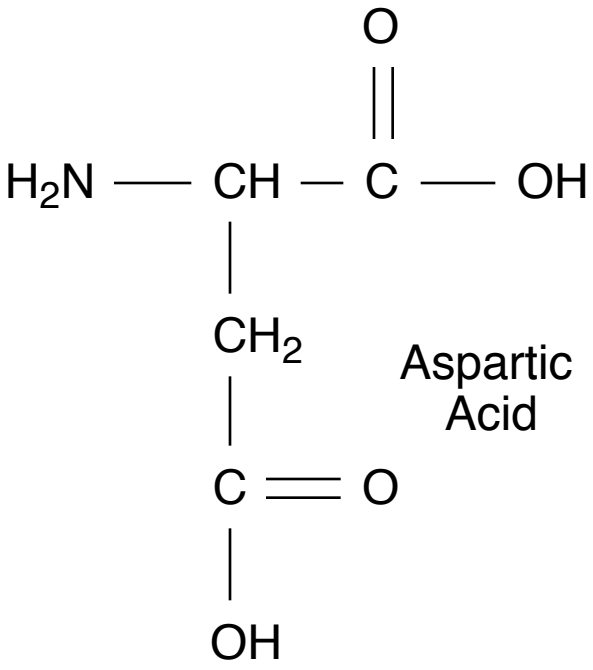
Glycine



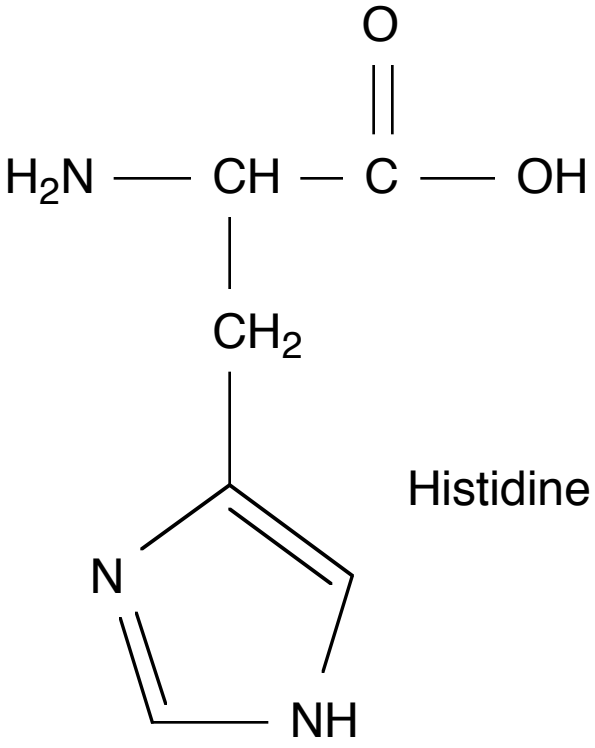
Alanine

Amino acids can have acidic residues, i.e., a residue may contain a carboxylic acid. Such amino acids are more acidic than so-called "neutral amino acids" (such as alanine and glycine). On the other hand, amino acids can contain an additional amine group, and this will enhance their basicity.

Amino acids containing a carboxylic acid residue are call acidic amino acids, and those containing g an amine residue are called basic amino acids. Aspartic acid is an example of an acidic amino acid. It is also one of the components of the sweetener aspartame. Histidine is an example of a basic amino acid. Note the presence of a cyclic amine in its residue:



Aspartic Acid



Histidine

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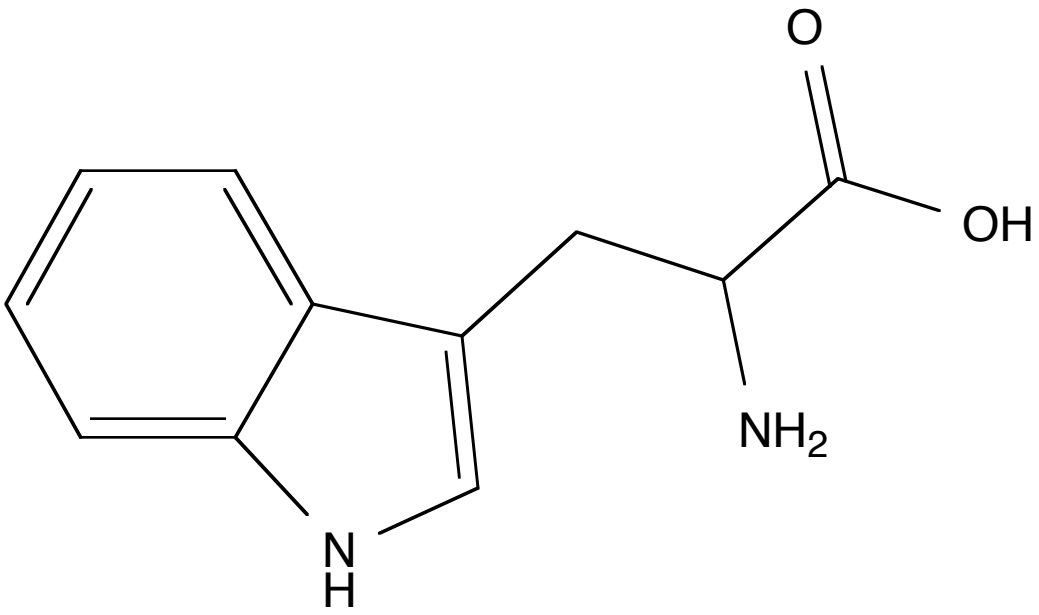
There is a world famous amino acid which everyone talks about around Thanksgiving. It is called tryptophan, and, allegedly, there is so much of it in turkey meat that we all fall into a stuporous sleep after eating our big meal. While there is some controversy about this, most scientists believe that we have fallen asleep because we have eaten so much. There is tryptophan in all our foods that we would be constantly asleep if the sleep-inducing powers of this nutrient were as strong as some believe Here is the structure of tryptophan. Cab you find the central carbon and satisfy yourself that it too has the requisite components of an amino acid? Is it a basic AA, a neutral AA or an acidic AA?

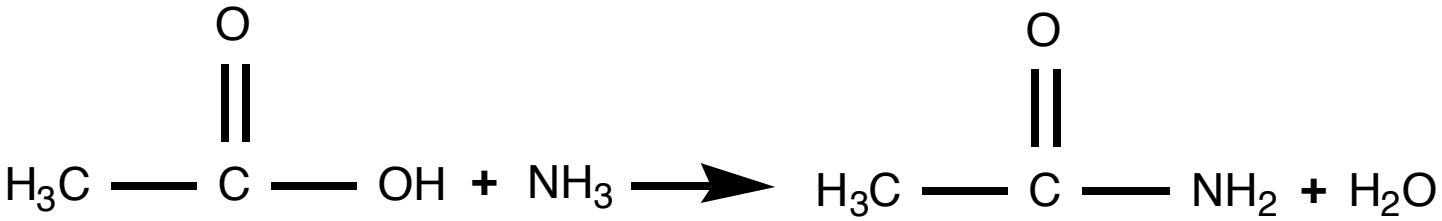


tryptophan

Peptides

One of the most important reactions (from a biological viewpoint) is the one that leads to the formation of an amide. (Another is the formation of an ester, which we have discussed in a previous handout).

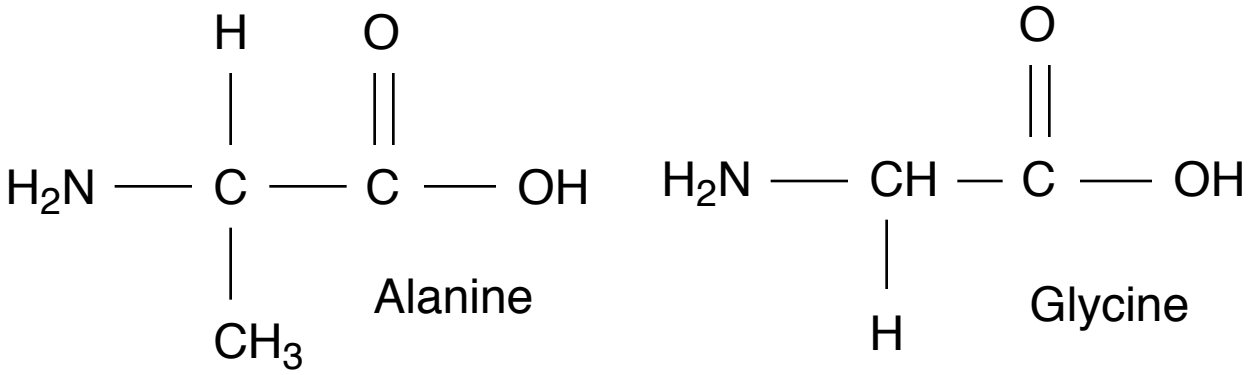
Typically, a simple amide can be formed by the reaction of ammonia with a carboxylic acid:



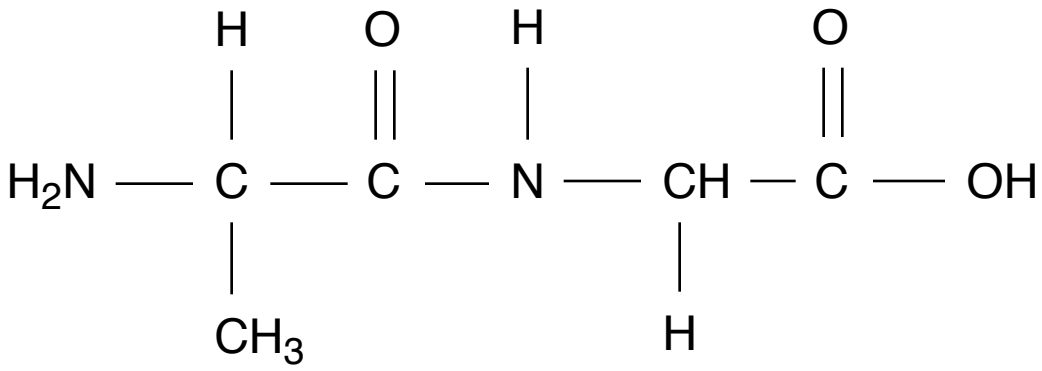
Notice how this is just another example of a "switch your partner" reaction, a so-called double displacement or metathesis reaction. In this reaction, an "H" atom splits off from the ammonia, and an –OH group splits off from the acid. The naked carbonyl group then reacts with the $-NH_2$ group to form the amide, and the "H" atom and –OH group are married to form water.

This same process occurs in the bonding together of two amino acids. The carboxylic acid end of one can form an amide linkage with the amine group of the other, splitting off a water as shown below. When the two combine we obtain a compound called a **peptide**. The amide linkage is sometimes called the **peptide linkage**, with the bond between the nitrogen and the carbonyl carbon referred to as the **peptide bond**.

We depict the formation of an example peptide by first presenting the separate amino acid. Any pair of amino acids will do; we have simply chosen the two simplest::



Now a water is split off (we don't show the water--just pretend it dripped off the paper) and the peptide is formed, complete with its brand spanking new peptide bond:



Ala-Gly

Actually this particular peptide is called a dipeptide, because it has two amino acids in it. But since each end of the dipeptide has either a carboxylic acid group or an amine group attached to it, the addition of subsequent amino acids via new peptide bonds can go on pretty much indefinitely. If you have three AA's hooked together, you get a tripeptide; more than that you get a polypeptide, up to a molecular weight of about 10,000. After that, we refer to these massively large peptides as proteins. An example of an important polypeptide is insulin, which contains a chain of 51 amino acids.