5.4 How Orders Translate into Assembled Boxes of Donuts

Clothespins and Donuts

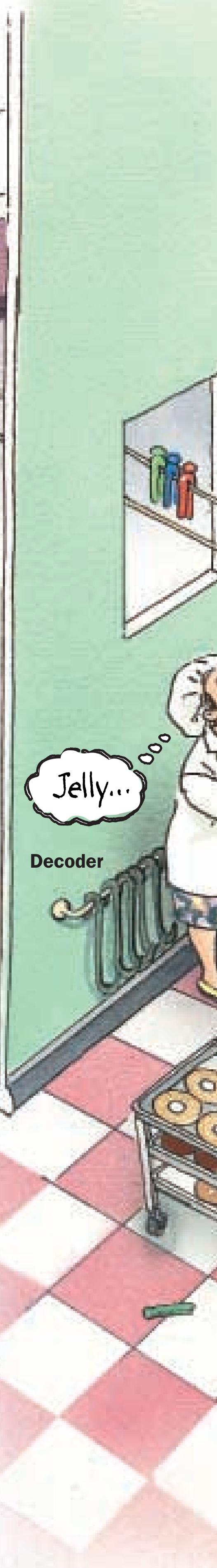
DoNutArama, a popular donut shop, makes twenty kinds of donuts. The donuts are so good that people buy big boxes of them. And each customer is very particular about having exactly the right kinds of donuts in exactly the right order in the box.

At first, the clerk at the counter tried shouting the orders to the kitchen staff, but they made too many mistakes. Written orders were out because the employees couldn't read the clerk's handwriting. Then someone remembered the colored clothespins in the basement. Maybe the clerk could somehow use the clothespins to transmit orders for donuts to the kitchen.

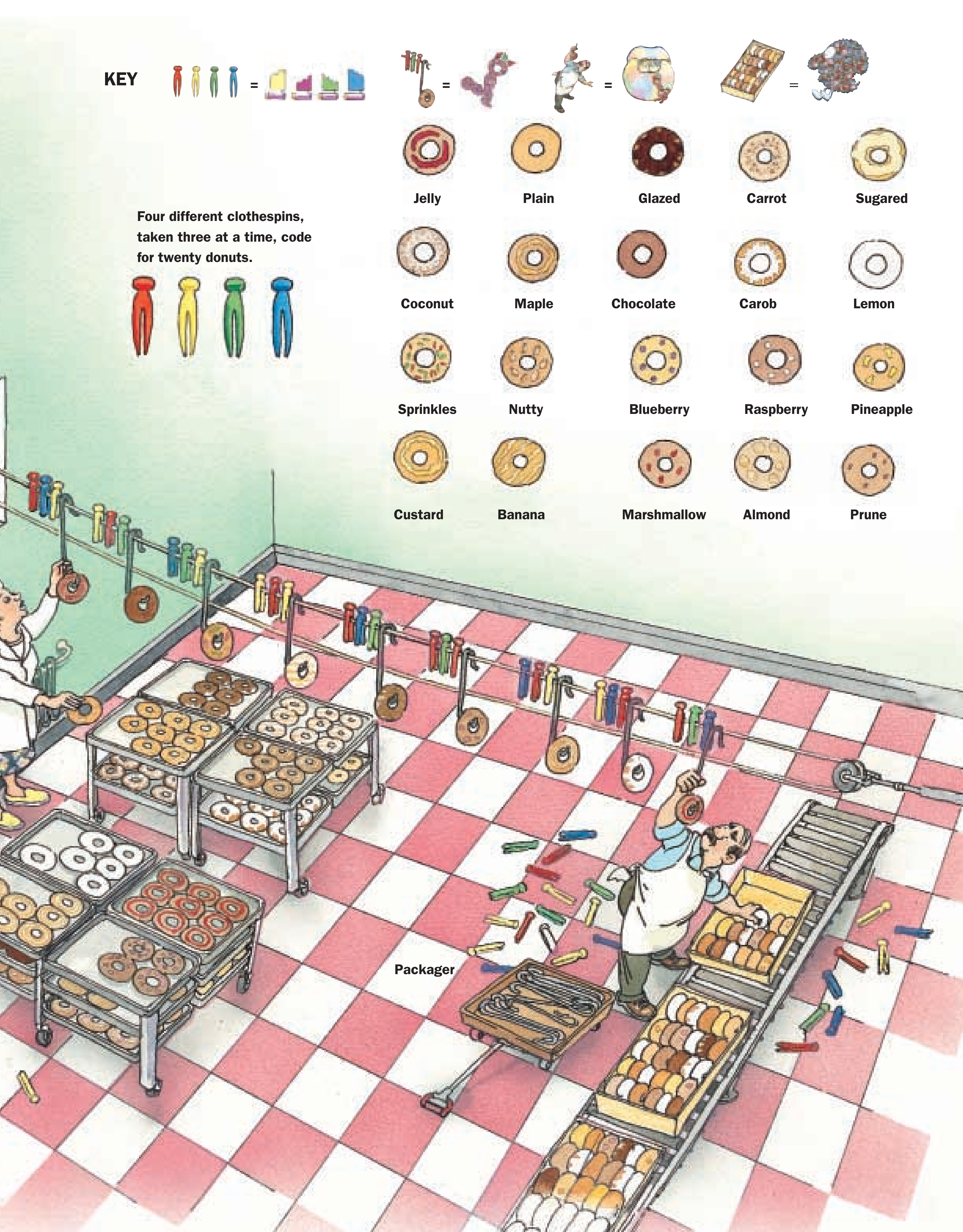
The clothespins came in four colors. The donuts came in twenty varieties.

What's the most efficient way to use four units to represent twenty units? The clerk worked out a code.

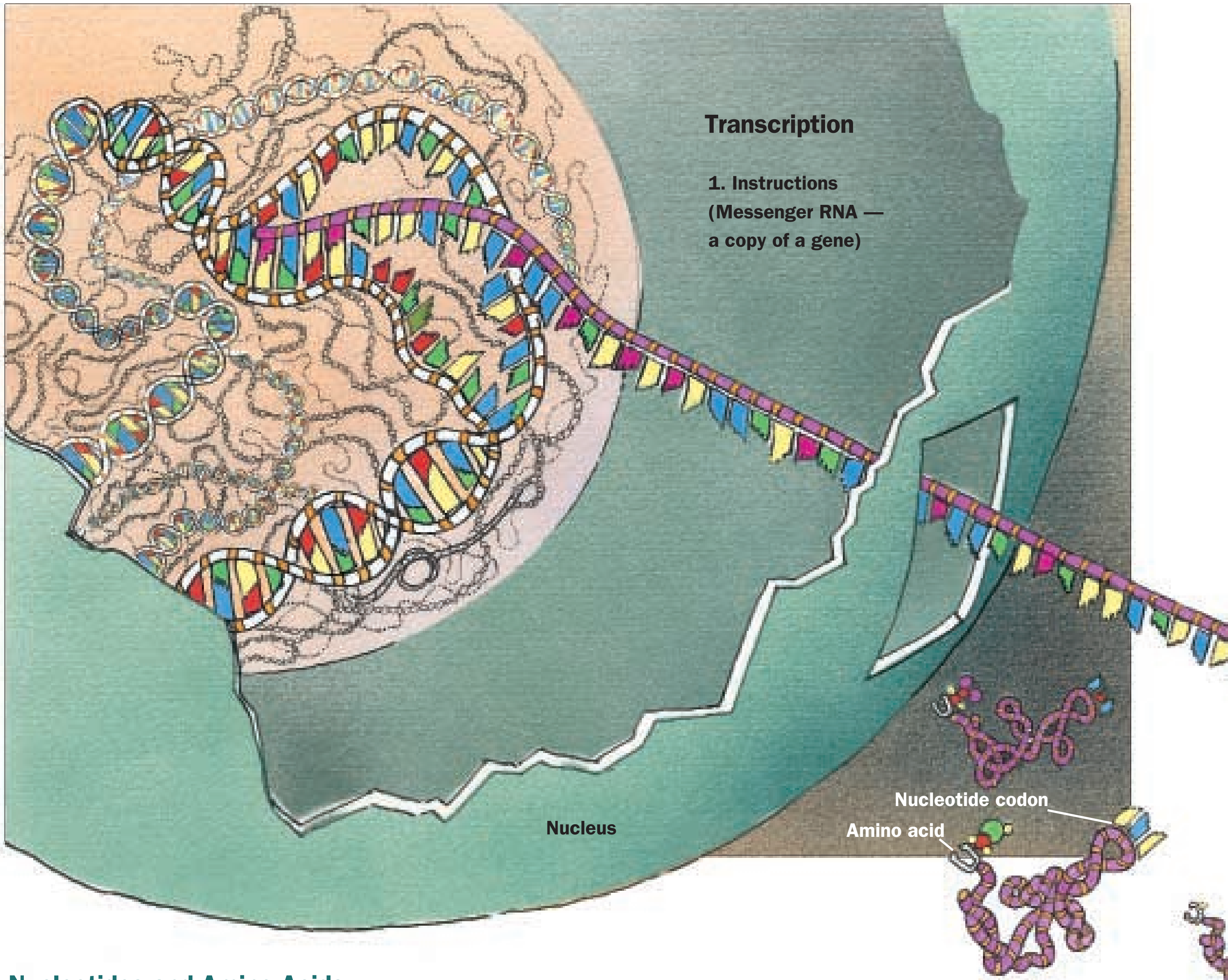
He first tried using combinations of two colors of clothespins: i.e., red + blue = jelly; yellow + red = chocolate; etc. He soon realized that there weren't enough different two-color combinations to represent all twenty donuts. But a three-clothespin code could produce sixty-four ($4 \times 4 \times 4$) possible combinations — more than needed for twenty different donuts. So he and his staff worked out and memorized a three-color code: red + blue + yellow = jelly; yellow + red + green = chocolate; etc. As the clerk took the orders, he put the correct color sequence on the line. In the kitchen, the decoder read the code, then hung the proper donut on the hook next to it. The packager took the donuts off the hooks and put them in their proper sequence in the box. Counter orders were transcribed into clothespin sequences and decoded into boxes of donuts, and things worked sweetly ever after.



WEB Connection
www.jbpub.com/connections


KEY
=
=
=
=
Four different clothespins, taken three at a time, code for twenty donuts.
Jelly
Plain
Glazed
Carrot
Sugared
Coconut
Maple
Chocolate
Carob
Lemon
Sprinkles
Nutty
Blueberry
Raspberry
Pineapple
Custard
Banana
Marshmallow
Almond
Prune
Packager

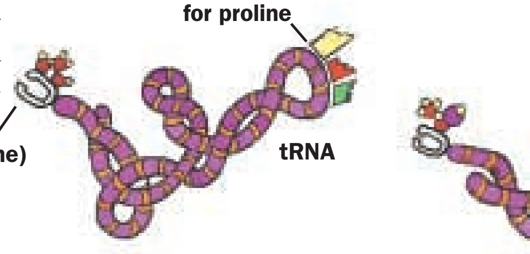
5.5 How DNA Information Translates into a Working Protein



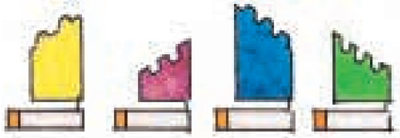
Nucleotides and Amino Acids

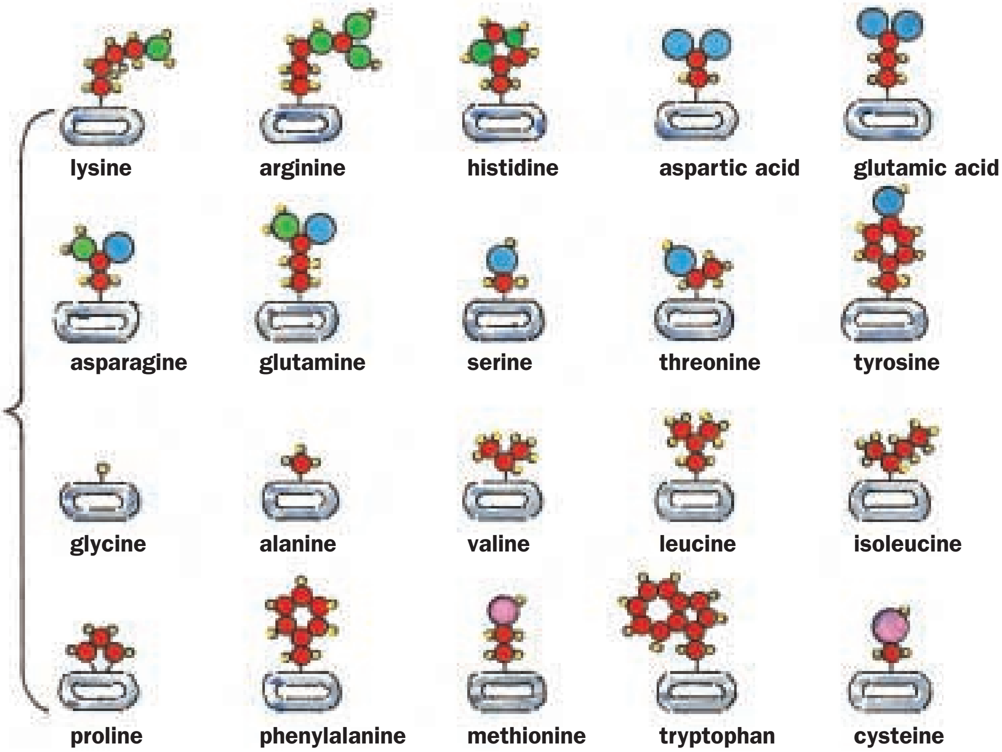
A DNA molecule is many, many nucleotides (clothespins) long. It is composed of genes, which are, on the average, some 1200 nucleotides long. Within each gene, the nucleotides are ordered in about 400 groups of three nucleotides apiece. Each nucleotide triplet (called a codon) gets translated into one of the twenty amino acids (donuts). The entire gene will be translated into a protein molecule that is about 400 amino acids long (the packaged donuts).

Here's how you make a protein. First, copy — transcribe — the sequence of nucleotides in a gene into a single strand of RNA (see Chapter 4, page 174) called messenger RNA (mRNA). Second, attach amino acids to small RNA molecules called transfer RNAs (tRNAs), or adaptors. These act like the decoder with her donut hook. Each adaptor recognizes a particular three-nucleotide codon. Third, bring the adaptors with their attached amino acids and the messenger RNA to a protein synthesis factory called a *ribosome* (the packager), which links up the amino acids to make the protein.

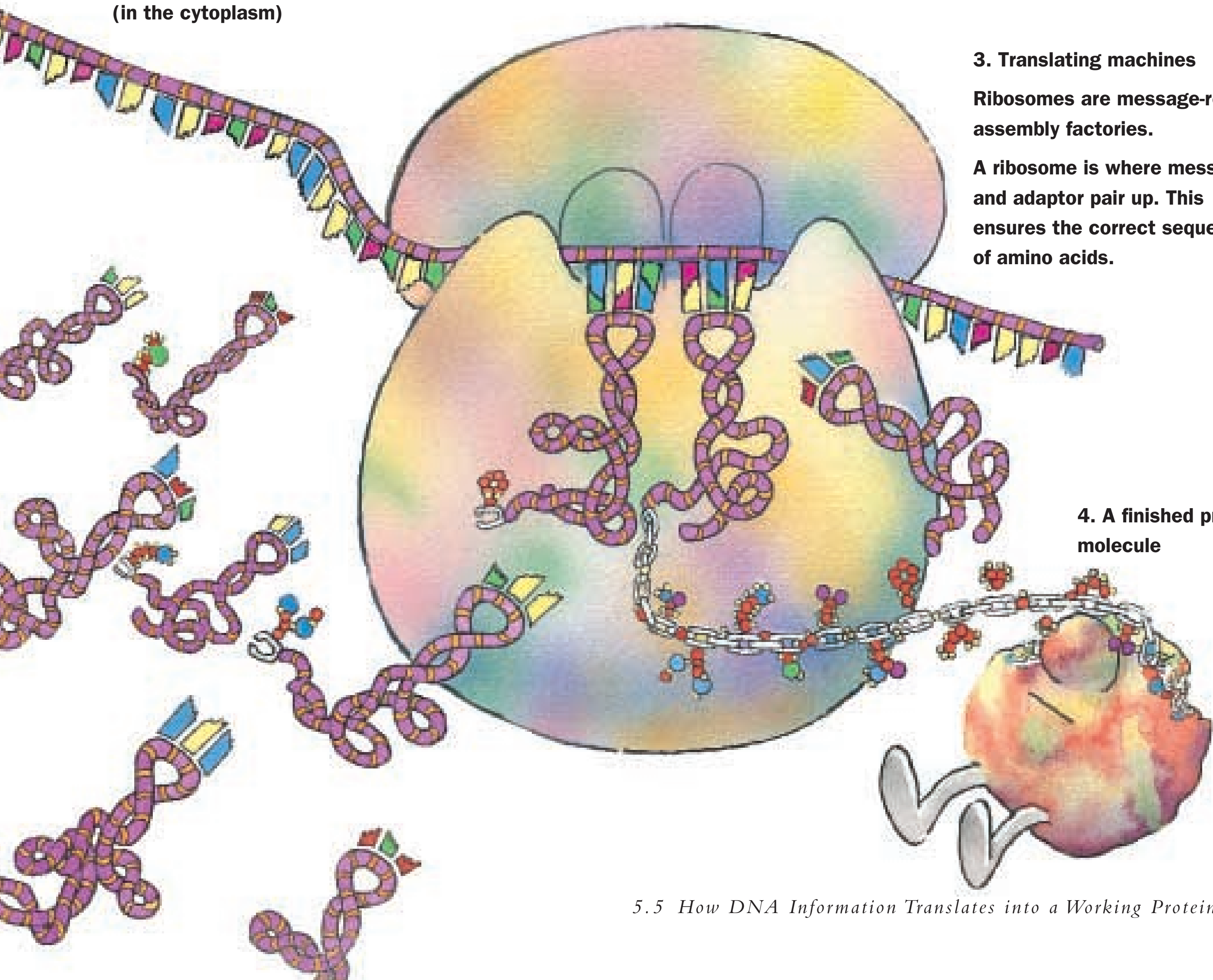


Four different nucleotides, taken three at a time, code for twenty amino acids.





Translation (in the cytoplasm)



3. Translating machines

Ribosomes are message-reading assembly factories.

A ribosome is where messenger and adaptor pair up. This ensures the correct sequence of amino acids.

4. A finished protein molecule