3d molecular designs

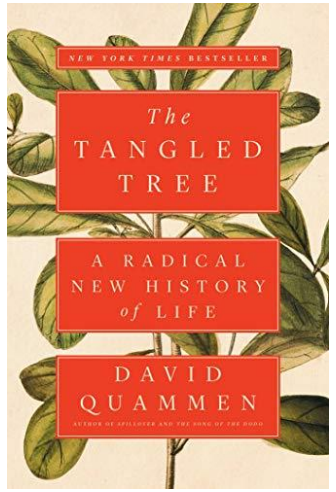
Transforming Science Learning

Translation / Protein Synthesis

Tim Herman

In the beginning,…i.e., in the years following the 1953 discovery of the structure of DNA….

…. But copying that material, for hereditary continuity, was one thing. Translating it into living organisms was another. Translated how? **By what steps does the information in DNA become physically animate?**



This fundamental matter— **how do bases designate aminos**?—became known as "the coding problem," to which **Francis Crick** addressed himself in the late 1950s.

Now he was sharing his office, his pub lunches, his fevered conversations, and his blackboard with another scientist, **Sydney Brenner**, rather than with Watson. One colleague at the Cavendish, upon early acquaintance with Crick, concluded that "his method of working was to talk loudly all the time."

from,…. **The Tangled Tree: A Radical New History of Life** by David Quammen

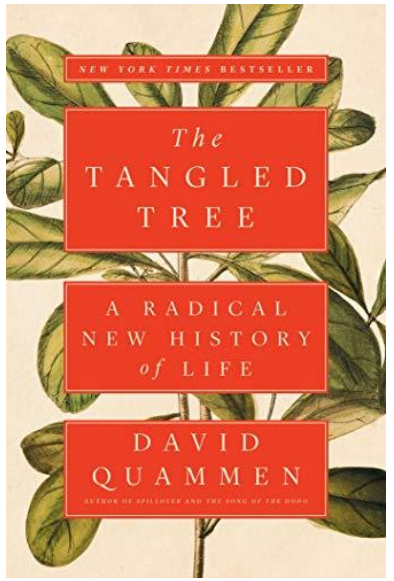
Ribosomes as assembly machines…

Then suddenly Brenner let out a “yelp.” He began talking fast. Crick began talking back just as fast. Everybody else in the room watched in amazement. ***Brenner had seen the answer, and Crick had seen him see it.*** The ribosome did not contain the recipe for the protein; it was a tape reader. It could make any protein so long as it was fed the right tape of “messenger” RNA.

They function as assembly mechanisms, taking in genetic information, plus raw material in the form of amino acids, and producing those larger physical products: proteins. In plainer words: ribosomes turn genes into living bodies. Because the proteins they produce become three-dimensional molecules, a better metaphor than Brenner’s tape-reader, for our own day, might be this: ***the ribosome is a 3-D printer***.

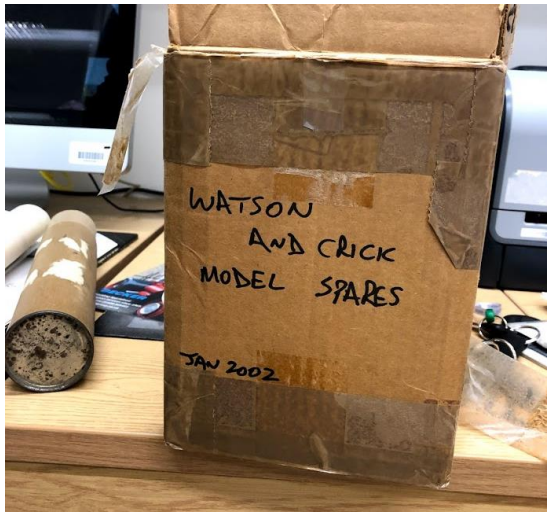
Francis Crick…. and molecular phylogenetics

Sometime in 1957 Crick gathered his thoughts and his informed guesses on this problem—about how DNA gets translated into proteins—and in September he addressed the annual symposium of the Society for Experimental Biology, convened that year at University College London. His talk "commanded the meeting," according to one historian, and "permanently altered the logic of biology." The published version appeared a year later, in the society's journal, under the simple title "***On Protein Synthesis.***"



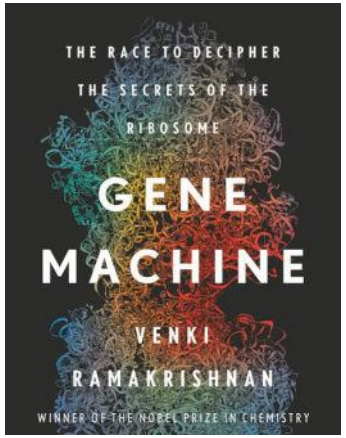
"Biologists should realize that before long we shall have a subject which might be called 'protein taxonomy'—the study of the amino acid sequences of the proteins of an organism and the comparison of them between species. It can be argued that these sequences are the most delicate expression possible of the phenotype of an organism and that vast amounts of evolutionary information may be hidden away within them."

The Laboratory of Molecular Biology (LMB)….at Oxford



The 70S bacterial ribosome…. an amazing achievement of modern structural biology.

Nobel Prize in 2009
to Venki Ramakrishnan,
Tom Steitz and Ada Yonath.



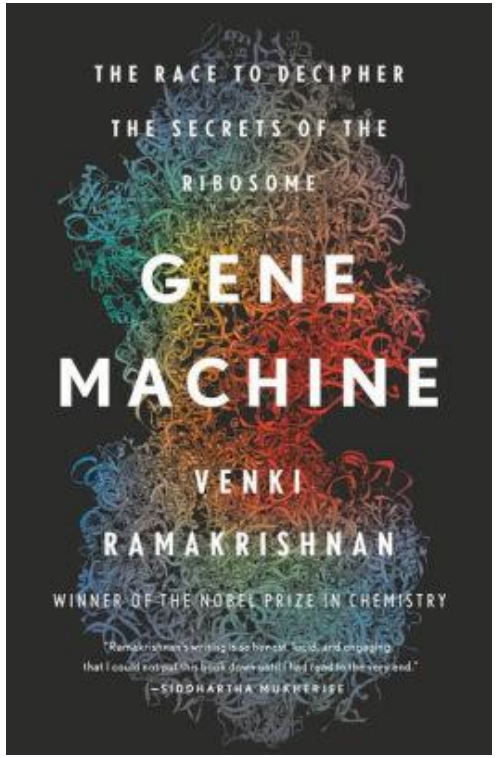
Small subunit: ~21 proteins and 16S rRNA…
…composed of 1542 nucleotides

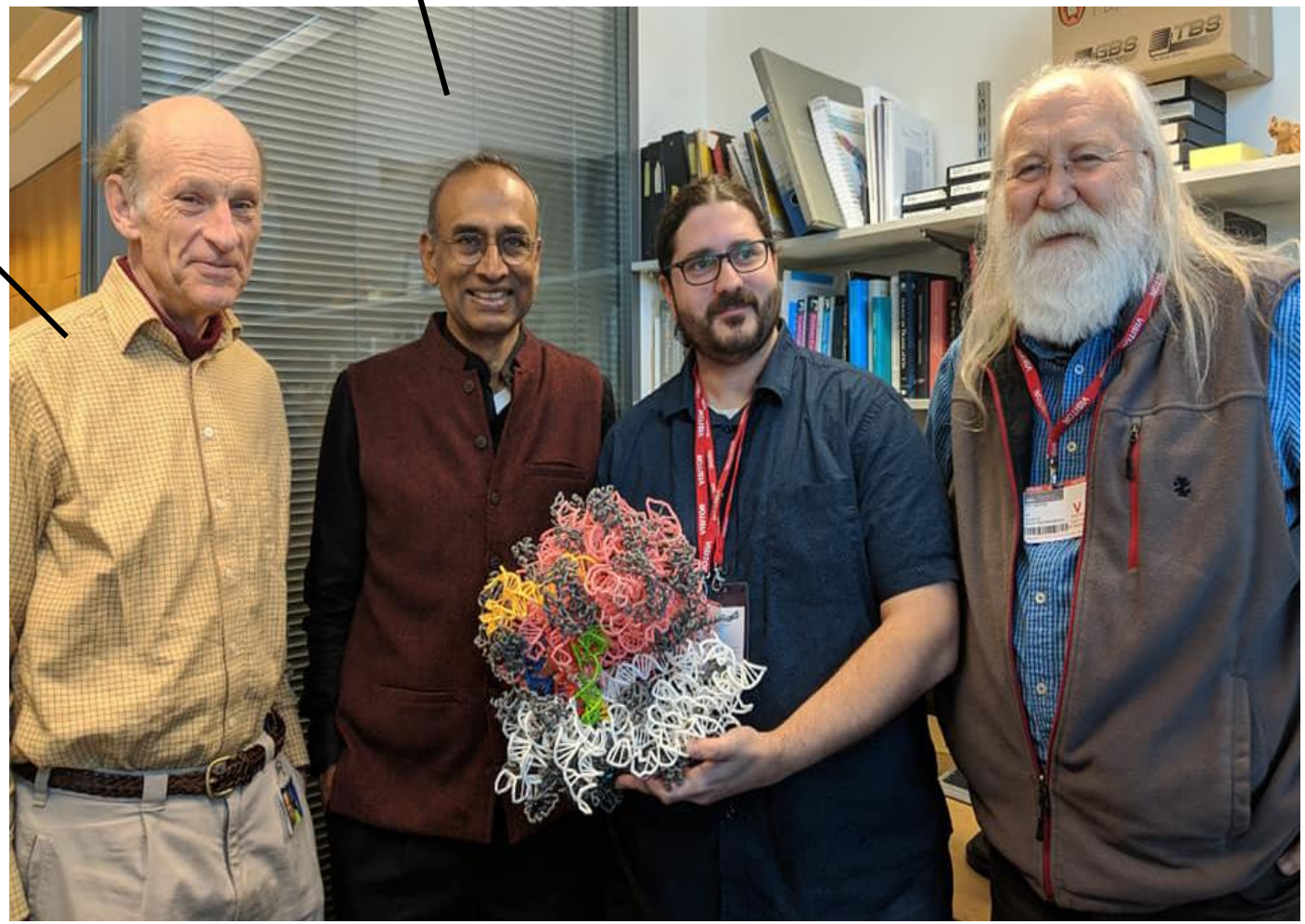
Large subunit: ~31 proteins and 23 S rRNA…
…composed of 2904 nucleotides

The ribosome is a ribozyme!

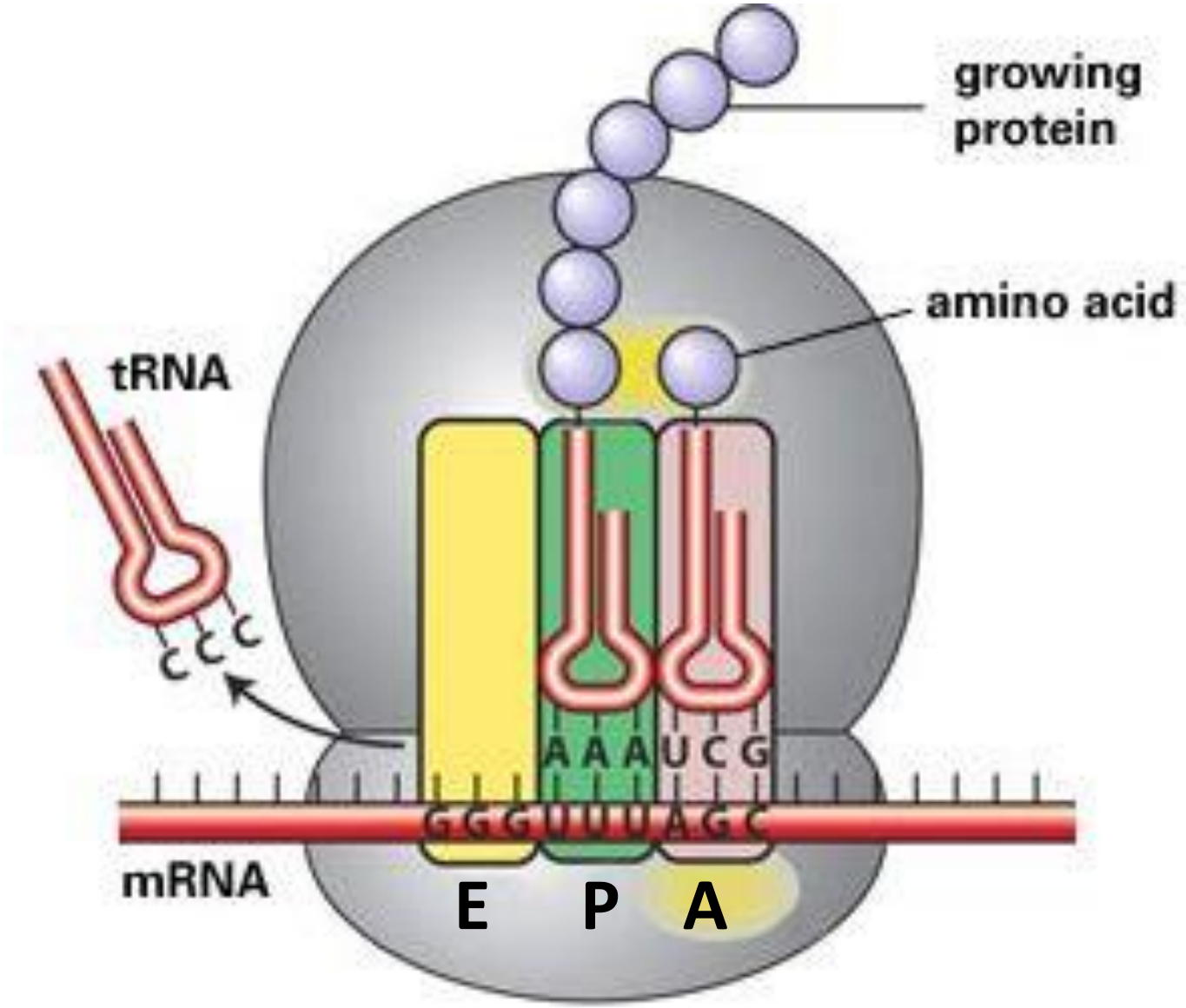
Venki Ramakrishnan

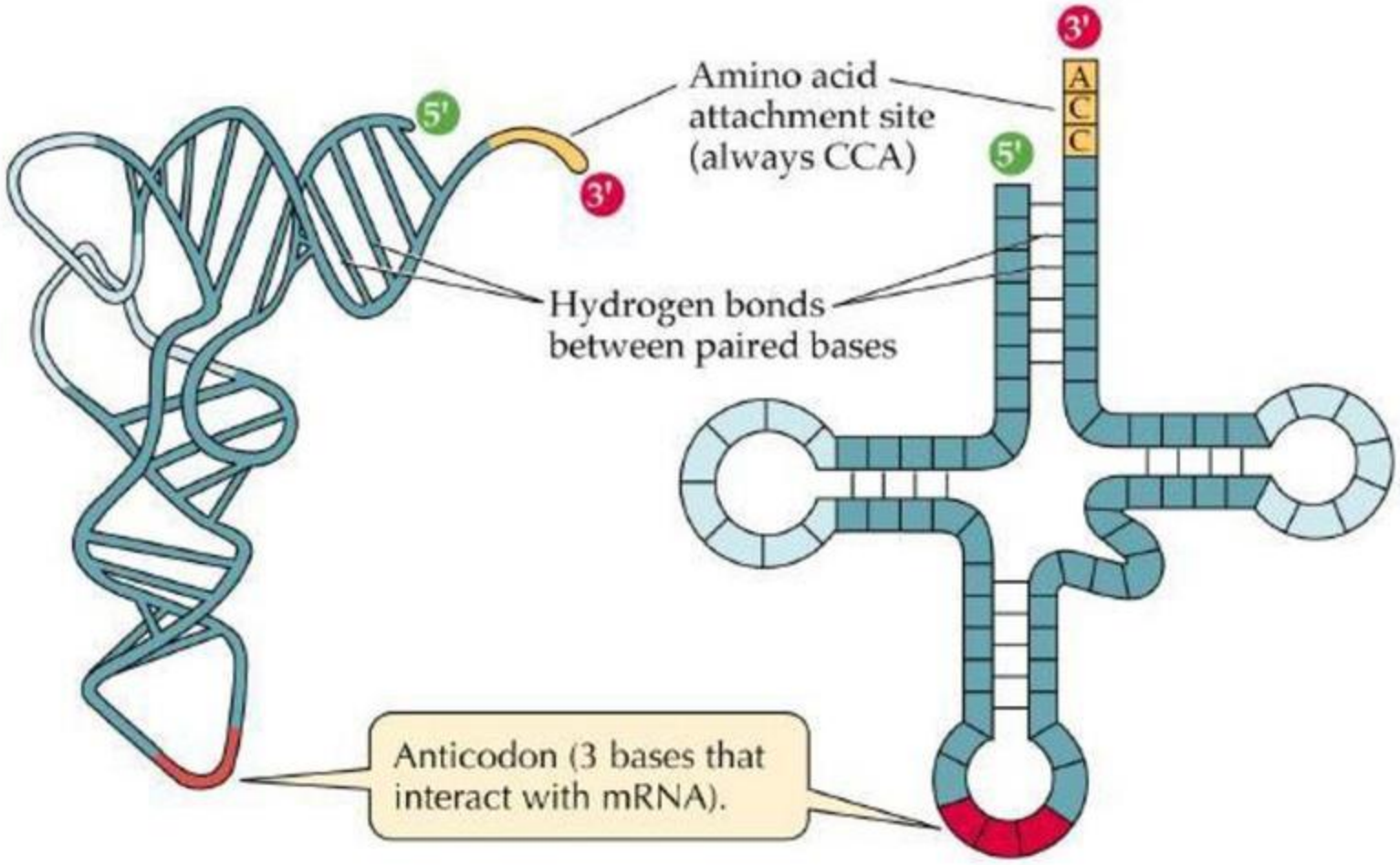
John Atkins





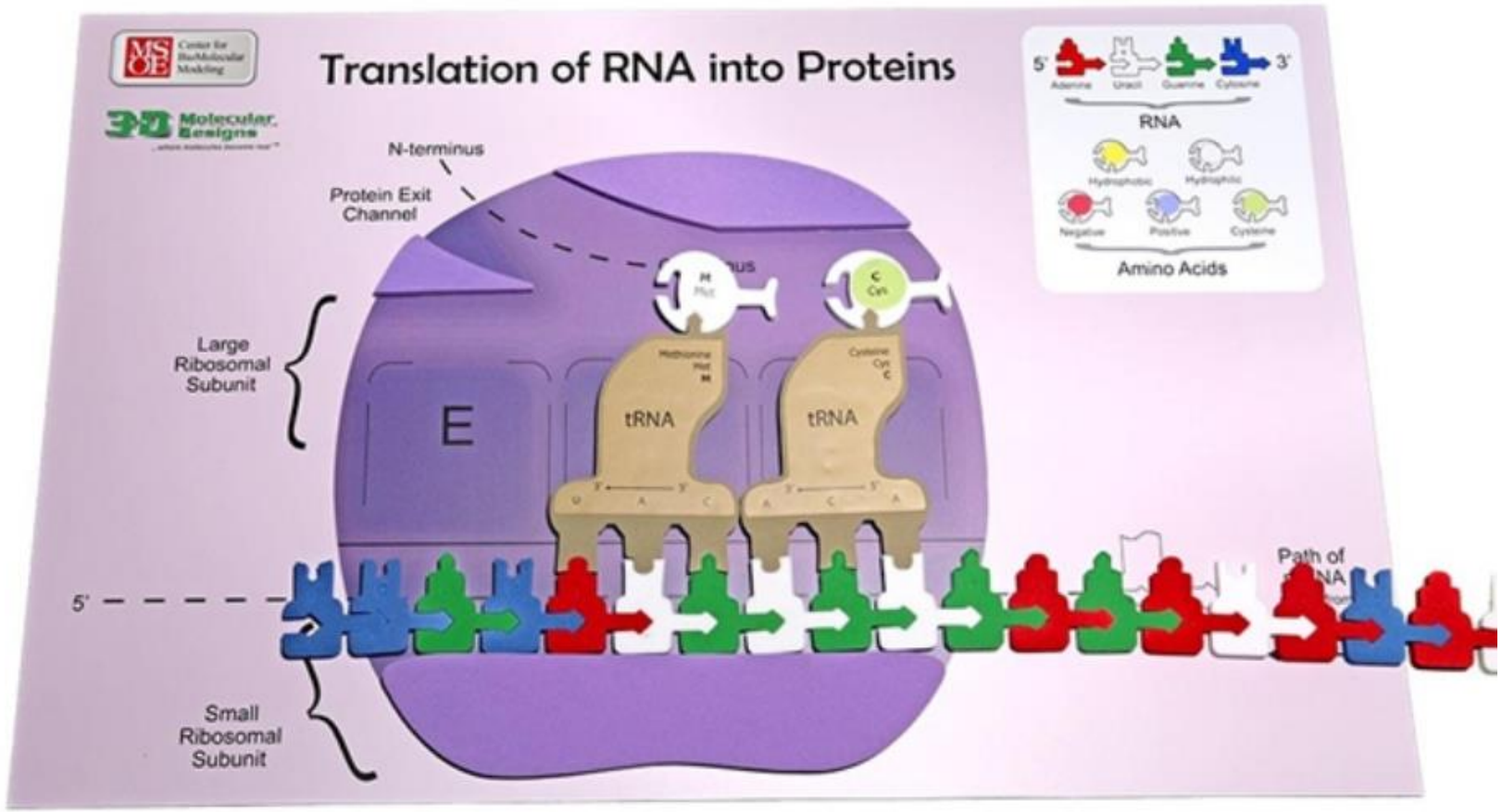
… a reMarkable model was presented to Venki Ramakrishnan


growing protein
amino acid
tRNA
C C C
A A A U C G
G G G U U U A G C
mRNA
E P A


3′
A
C
C
5′
Amino acid
attachment site
(always CCA)
5′
3′
Hydrogen bonds
between paired bases
Anticodon (3 bases that
interact with mRNA).

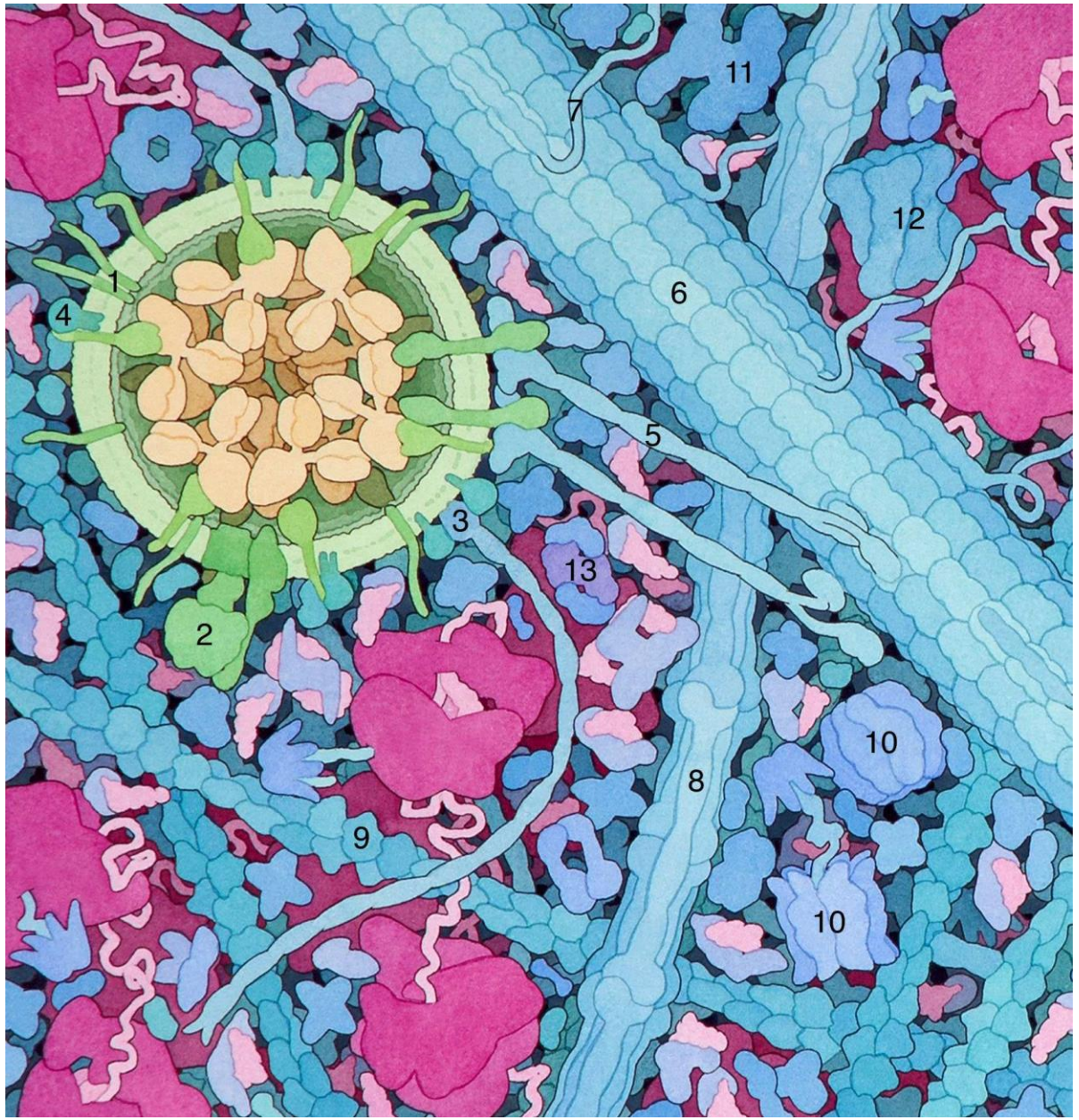

Amino acid
attachment site
A
A
G
3′
5′
Anticodon

Symbol used



remember,… all models are wrong!

What is the most plentiful molecule displayed in a Goodsell landscape?



Other topics….related to protein synthesis….

- **Initiation….how does the ribosome know where to start?**
- **Peptidyl transferase….** “the ribosome is a ribozyme”.
- **The translocation mechanism….**
- **Rough and Smooth endoplasmic reticulum….**
- **Protein Synthesis is a stochastic process…..**
- **The ribosomal “decoding center”….** A1492, A1493,G530 and C1054

https://pdb101.rcsb.org/motm/121