May 21, 2001

ID number _____

Biochemistry Cumulative Exam

You may not use any materials on this exam except your brain and a pen/pencil.

There are 3 questions dealing with prebiotic evolution in this exam. Pick **any 2** and answer them **fully**. I have given you 6 blank pages to write your answer — use them well! The point of view to take is not to "write down the answer" but to develop an argument. The fact is that we do not know what happened during the prebiotic period on this planet, and we likely never will (unless somebody builds a time machine…). However, anyone with current knowledge of basic biochemistry and molecular biology and some curiosity can speculate as to what **might** have happened, what would be a reasonable course of events, *etc.* Assume that you have to **convince** me that your point of view has merit. Develop it, make your points, and try to prove that what you propose is reasonable and fits with what we already know.

OPTIONAL: If you have given a lot of thought to prebiotic evolution and have some interesting, well-developed ideas on how it happened, and your ideas do not fit so well into the specific questions that I have asked, then you can forego the questions. Use the 6 pages to explain your concepts in as much detail as possible.

Grade:

PASS (you convinced me)

FAIL (you need to think about it some more)

1) There is a well-known "chicken & egg" problem in molecular biology:
Which came first — nucleic acids or proteins? While nucleic acid is required to encode polypeptides, proteins are required for the information in nucleic acid to be expressed.

In the "prebiotic soup" experiments of Miller, Urey, and their followers, they found many amino acids (*e.g.* Gly, Ala, Val, Ile, Pro, Asp, Glu, Ser, Thr…), nucleobases (adenine, guanine, cytosine, uracil, xanthine, and hypoxanthine), as well as sugars. Moreover, under some conditions short polypeptide and nucleic acid polymers were detected. Thus, one can imagine both polypeptides and nucleic acids emerging early in the game.

The **Question** is:
Which molecules served as genetic material, which served as catalysts, and what was the link between these 2 functions?

One answer that has been proposed to solve this dilemma is the "RNA first" hypothesis, in which RNA would fill both roles. If you decide to defend this hypothesis, develop it fully and try to show how it could explain all the early functions of the prebiotic "life forms" that would have existed early on.
(*i.e.* don't just say "RNA came first because it can serve as genetic material and catalyst" — that is **not** what I am looking for!)

2) Let us assume, for the sake of argument, that the "RNA first" hypothesis holds true. Now the question is: **how do you make the jump from RNA to protein?** If you think about the process of translation, although RNA is heavily involved, many of the steps also require proteins. How can you do translation with RNA alone? How would the connection be made between the genetic information and the sequence of the polypeptide chain? Envision a biochemical system completely based on RNA and show how it could produce an encoded polypeptide using only RNA as catalyst. Assume that free amino acids and high-energy nucleotide triphosphates are freely available.

3) Eventually, the molecules that encode hereditary information and the catalysts have to leave the "prebiotic soup" and become encapsulated by some kind of membrane system (*i.e.* a "proto-cell"). Is this important or necessary to drive further evolution of biological molecules? Why? And at which stage do you think it could occur? Explain exactly how you think it might have occurred.