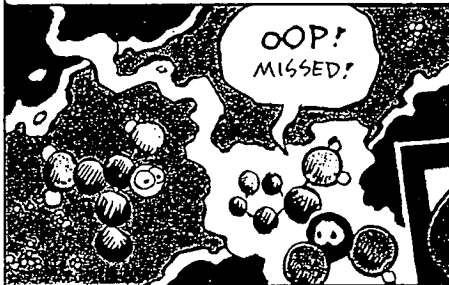


Science Reading Selection: SOUP OR SANDWICH ?

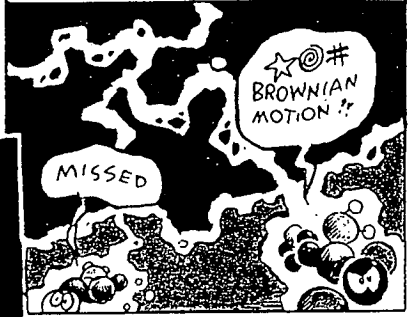
THERE'S SOMETHING WRONG IN THE **ORGANIC SOUP**, THAT NUTRIENT-RICH BROTH WHERE LIFE BEGAN - SUPPOSEDLY...



... WHERE SIMPLE ORGANIC BUILDING BLOCKS COMBINED INTO GIANT MOLECULES - SOMEHOW...



... WHERE GENE REPLICATION BEGAN - BY SOME UNKNOWN PROCESS...



SOUP OR SANDWICH?

IT'S ONLY THE ORIGIN OF LIFE...

THE PROBLEM IS THAT SCIENTISTS WHO HAVE STUDIED THE ORGANIC SOUP IN DETAIL HAVE DECIDED THE THEORY IS **LOGICALLY PARADOXICAL, INCOMPATIBLE WITH THERMODYNAMICS, AND EVEN EXPERIMENTALLY REFUTED!**

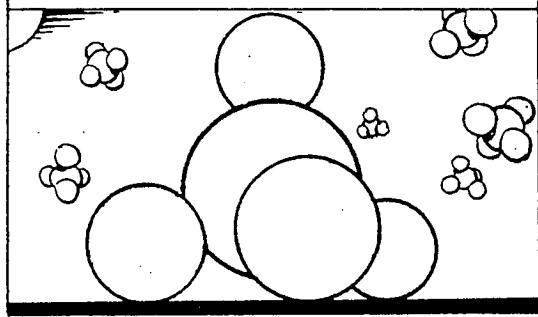
BUT SCIENCE HAD NO GOOD ALTERNATIVE - UNTIL NOW. IN 1988, THE GERMAN CHEMIST **GÜNTER WÄCHTERSHAUSER** (G.W. FOR SHORT!) PROPOSED A NEW THEORY OF THE ORIGIN OF LIFE.



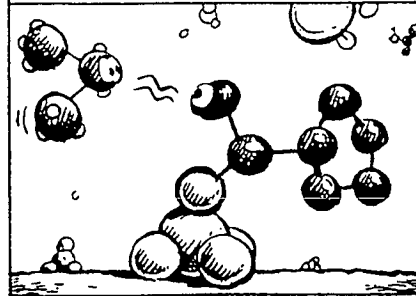
G.W. IMAGINES A FLAT, CRYSTALLINE, MINERAL SURFACE SUBMERGED IN HOT SALT WATER. THE SURFACE IS RICH IN SULFUR AND HAS A POSITIVE ELECTRIC CHARGE - **PYRITE**, POSSIBLY, SUCH AS YOU'D FIND AT AN UNDERSEA VOLCANIC VENT:



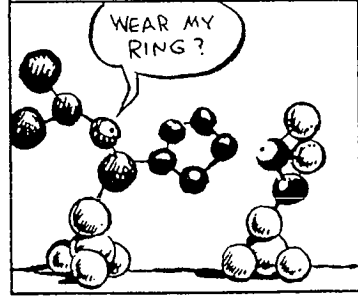
THE CHARGED SURFACE ATTRACTS NEGATIVELY CHARGED IONS, LIKE THESE PYRAMID-SHAPED **PHOSPHATE** GROUPS.



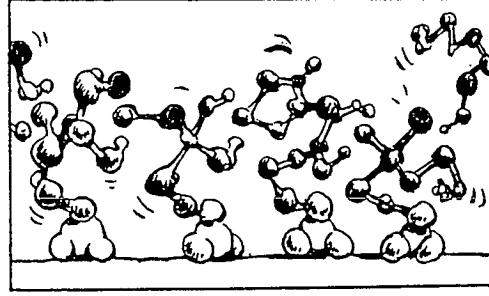
THESE LINK UP WITH WHATEVER PASSES BY: CARBON, NITROGEN, ETC. CARBON IS NICE, BECAUSE IT MAKES CHAINS AND RINGS.



ANCHORED BY THE ELECTRIC FIELD, THESE MOLECULES BEGIN REACTING WITH EACH OTHER.



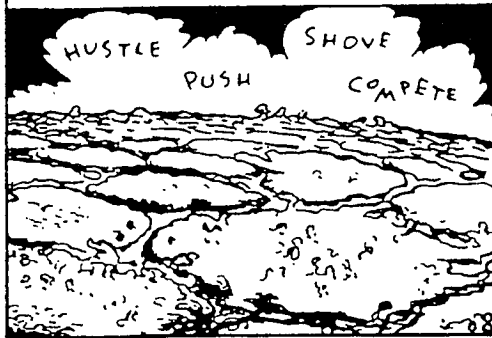
SOME OF THE REACTIONS FORM **AUTOCATALYTIC CYCLES** - SEQUENCES OF REACTIONS THAT TEND TO PROMOTE, OR CATALYZE, MORE OF THEMSELVES.



AN AUTOCATALYTIC CYCLE IS A SORT OF CHEMICAL FEEDBACK LOOP. THE SIMPLEST EXAMPLE WOULD BE TWO CHEMICALS, CALL THEM **A** AND **B**, WHERE **A** CATALYZES **B**, AND **B** CATALYZES **A**. THE RESULT ~ A LOT MORE **A** AND **B** ~ IS A KIND OF NON-GENETIC REPRODUCTION."



SOON, VARIOUS AUTOCATALYTIC CYCLES JOISTLE FOR SPACE ON THE PLANE. THE MORE EFFICIENT DRIVE OUT THE WEAK. DETACHMENT MEANS DEATH.



THIS CHEMICAL EVOLUTION PRODUCES MANY OF THE REACTION SEQUENCES WE FIND IN THE METABOLISM OF THE LATER LIVING CELL



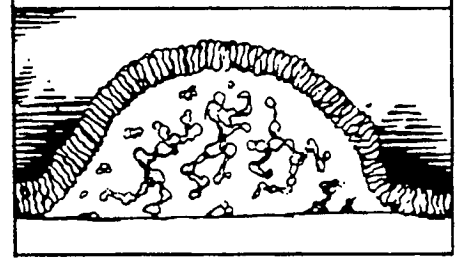
METABOLIC REACTIONS HAVE FATTY BY-PRODUCTS: **LIPIDS**, THE STUFF OF MEMBRANES.



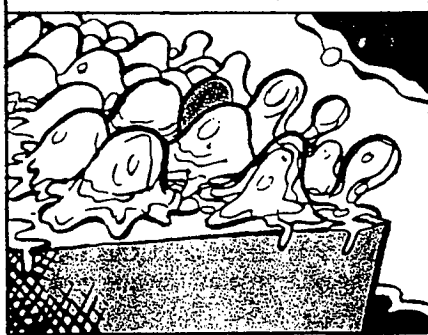
FATTY GLOBS EVENTUALLY ENGLUF WHOLE BUNCHES OF REACTION CYCLES.



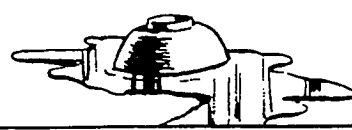
NOW THERE'S AN **ORGANIC SOUP** - BUT IT'S CONCENTRATED UNDER A FATTY, WATERPROOF MEMBRANE! WITHIN THIS SHELTER, REACTION CYCLES CAN BREAK AWAY FROM THE MINERAL SURFACE WITHOUT DRIFTING AWAY.



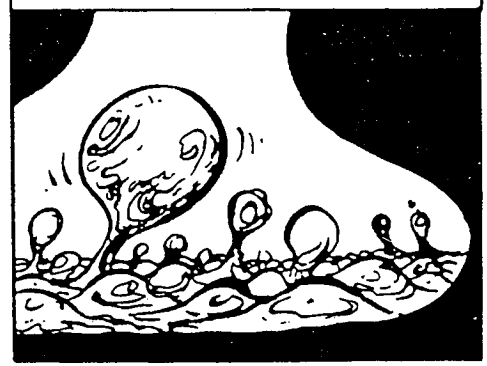
INSIDE THESE BLISTERS, SAYS WÄCHTERSHAUSER, **GENES** AND **ENZYMES** EVOLVE TO REGULATE THE REACTIONS ALREADY GOING ON.



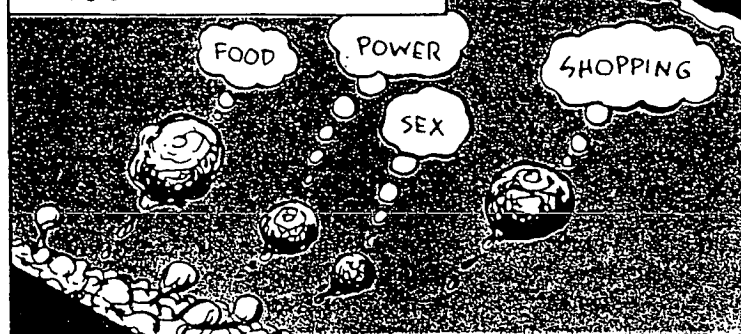
NOTE HOW G.W.'S IDEAS TURN THE ORGANIC SOUP ON ITS HEAD. THE **SOUP-ISTS** MAINTAIN THAT GENES AND ENZYMES APPEARED FIRST AND CREATED METABOLISM LATER, AS A WAY OF FEEDING THEMSELVES MORE EFFICIENTLY. THE **SANDWICH THEORY**, BY CONTRAST, SAYS THAT GENES AND ENZYMES EVOLVED ON TOP OF ALREADY EXISTING METABOLIC PROCESSES.



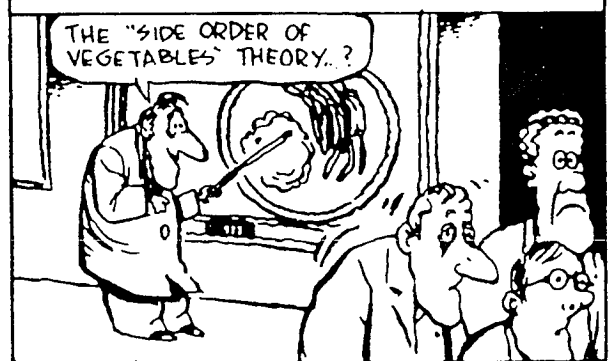
THE SYSTEM IS NOW SELF-CONTAINED. THE MEMBRANE COMPLETELY SURROUNDS IT...



AND AT LAST, TRUE CELLS BREAK FREE TO COLONIZE THE WORLD WITH THEIR FAMILIAR, PRIMORDIAL, **BIOLOGICAL URGES**.



ALTHOUGH MANY DETAILS REMAIN TO BE FILLED IN, THE "OPEN-FACED SANDWICH" THEORY IS GOING TO DRIVE OUT ITS SCIENTIFIC COMPETITION.



Science Reading Selection: SOUP OR SANDWICH ?

PART I: COMPREHENSION

1. Using a dictionary or science book, look up the following words and write a sentence which explains its meaning.

- a. organic-
- b. molecule-
- c. ion
- d. catalyze
- e. reproduction
- f. genes
- g. metabolism
- h. replication

2. According to the cartoon, what are the two groups who have theorized about the origin of life? _____

3. Which was the original theory? _____

4. Explain the *organic soup theory*. _____

5. What happened in 1988? _____

6. Who proposed the new theory? _____

Science Reading Selection: Soup or Sandwich?

7. What is an autocatalytic cycle? _____

8. What happens to the cycles that are less efficient? _____

9. What is formed when the fatty globs engulf whole bunches of reaction cycles?

10. What does the waterproof membrane prevent from happening? _____

11. What evolves inside the waterproof membranes? _____

12. How do the "soupists" and the "sandwichists" differ regarding the genes and enzymes? _____

13. When the system is totally self-contained, what happens? _____

14. What are the 4 urges of true cells? _____

Science Reading Selection: Soup or Sandwich?

15. What effect will the "open faced sandwich" theory probably have on the "soup" theory? _____

PART II: CONCLUSIONS: In the space below, write a summary of the information presented in the cartoon "Soup or Sandwich" or create a simplified cartoon version for other students.