



THE MOLECULAR HISTORY OF LIFE

FALL 2023





RECAPPING SESSION 1

- **MOLECULAR REQUIREMENTS FOR LIVING SYSTEMS:**

- 1) MAINTAINING STRUCTURE → METABOLISM
- 2) CLEAR BOUNDARIES WITH THE ENVIRONMENT
- 3) INFORMATION
- 4) REPLICATION
- 5) CHANGE OVER TIME → EVOLUTION

- **EARLY EARTH:**

- PREBIOTIC SYNTHESIS OF ORGANIC MOLECULES
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EXTANT LIVING SYSTEMS

- **CELLULAR PROCESSES**

- PROTEINS

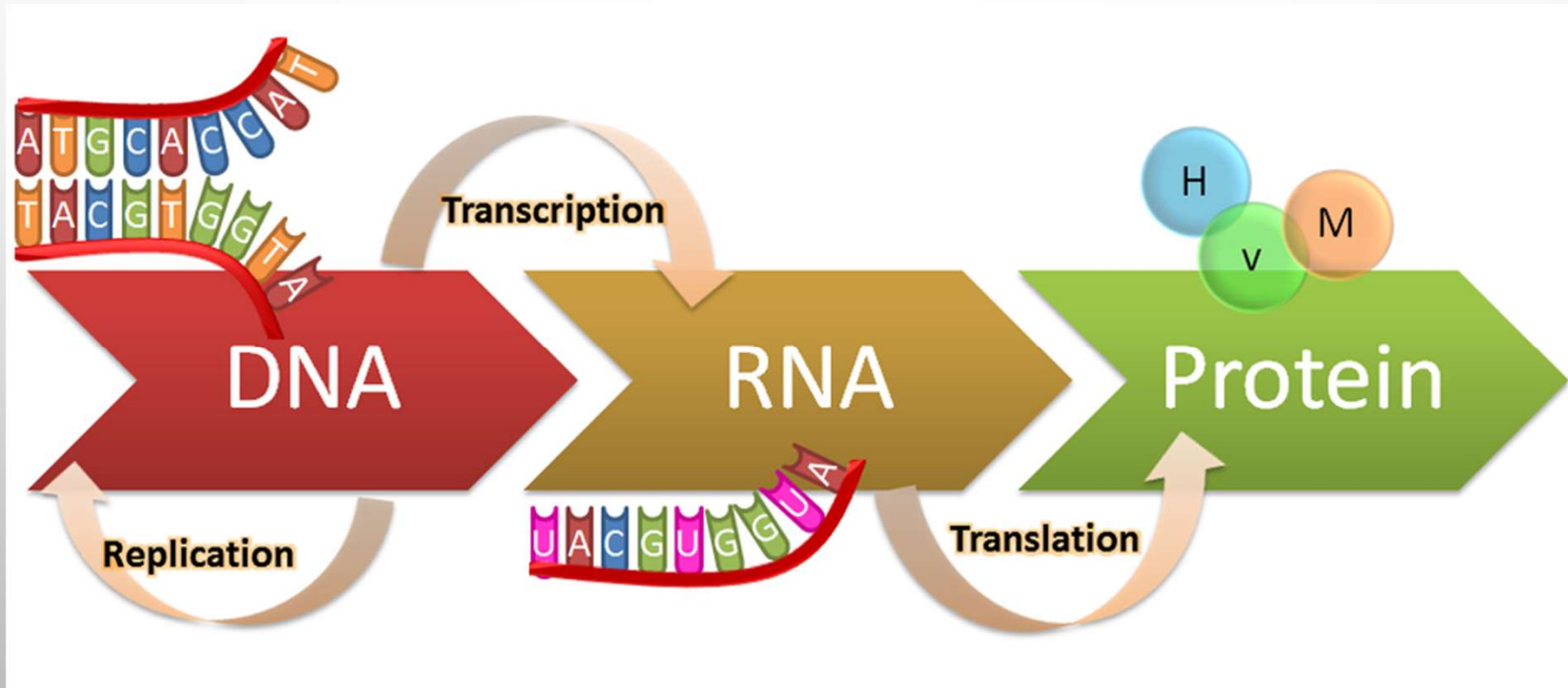
- **INFORMATION**

- ENCODED IN DNA

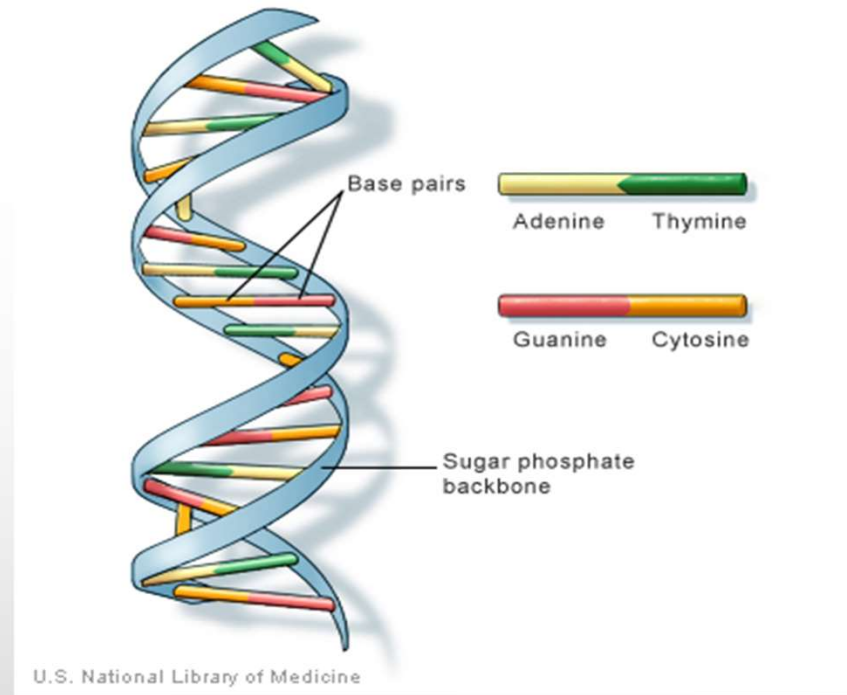
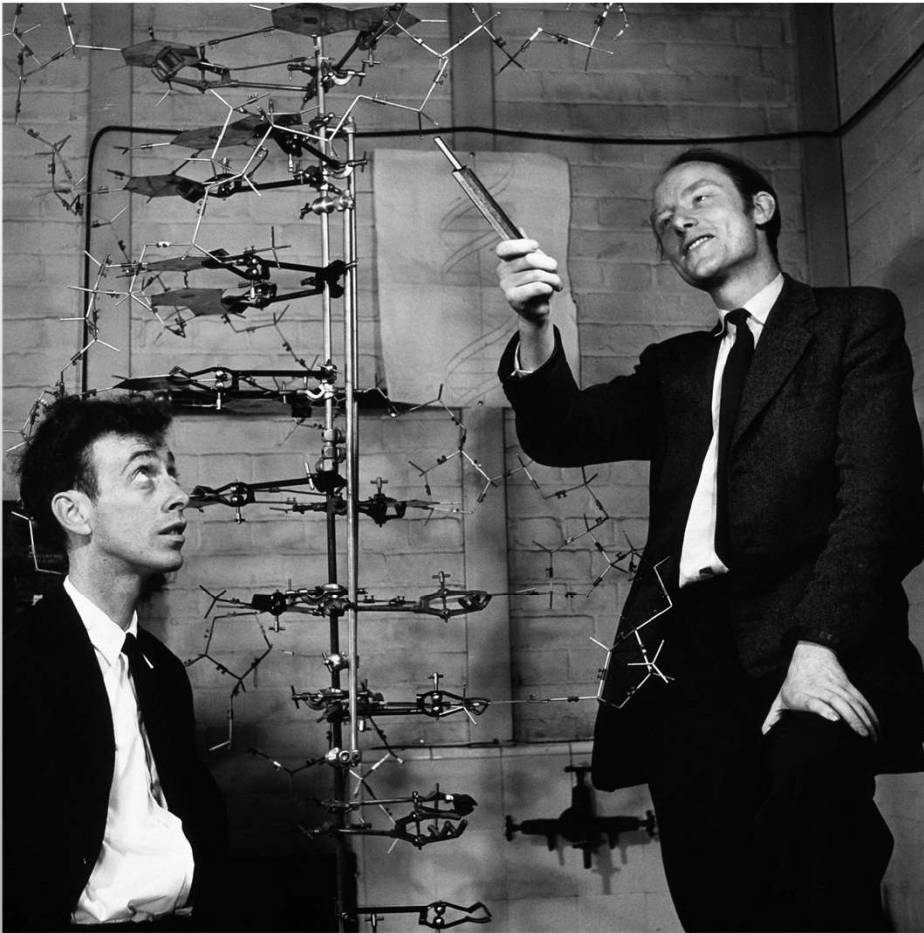
- **LINKING INFORMATION AND CELLULAR PROCESSES**

- RNA

THE INFORMATION HIGHWAY: FROM CODE TO CELLULAR FUNCTION

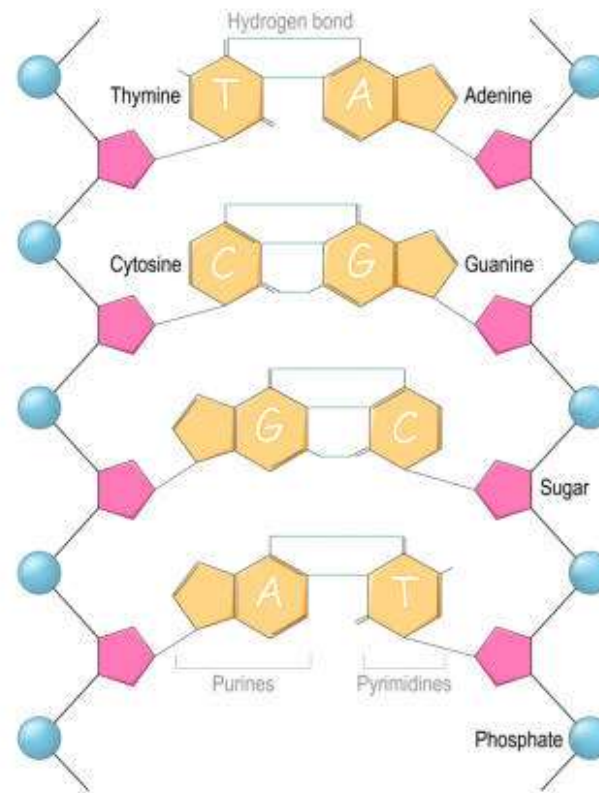


THE STRUCTURE OF DNA – WATSON AND CRICK – 1953

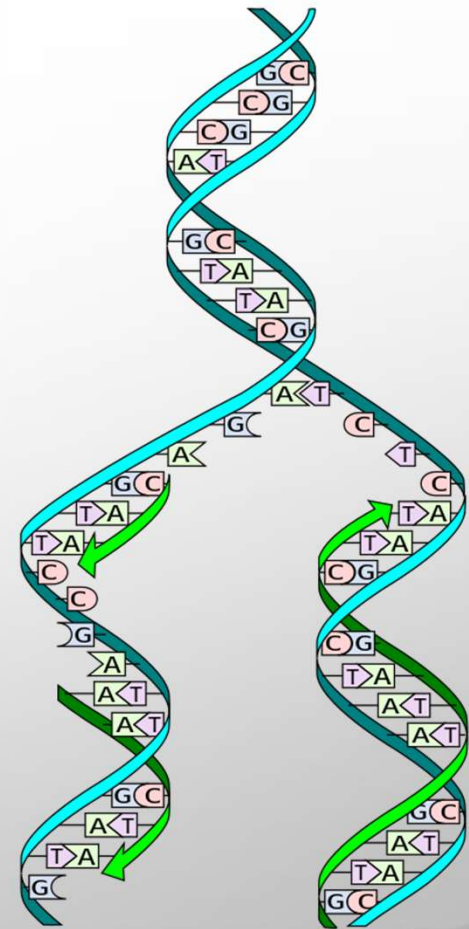
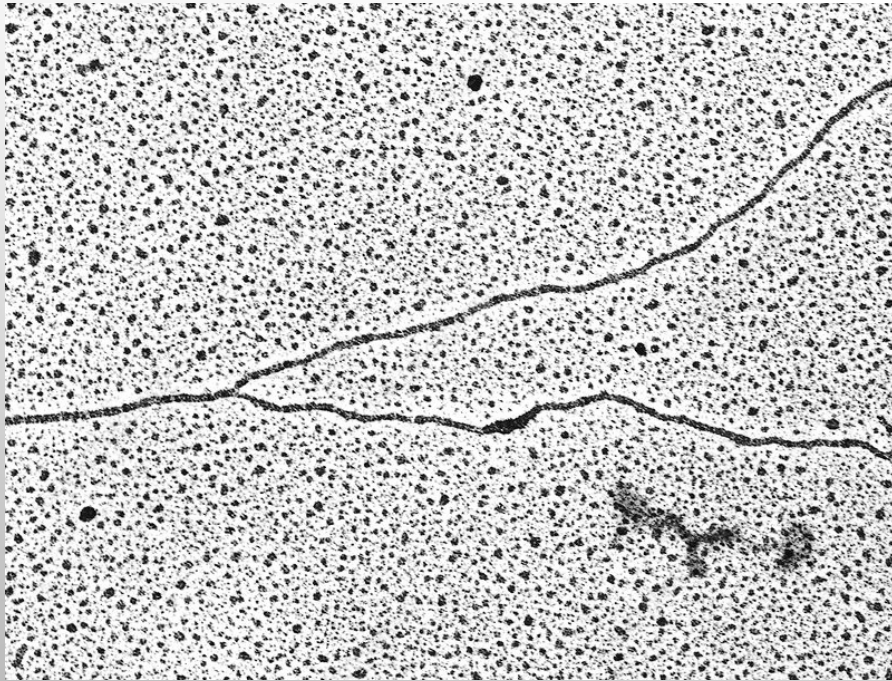


“It has not escaped our notice that the pairing we have postulated immediately suggests a possible copying mechanism for the genetic material”

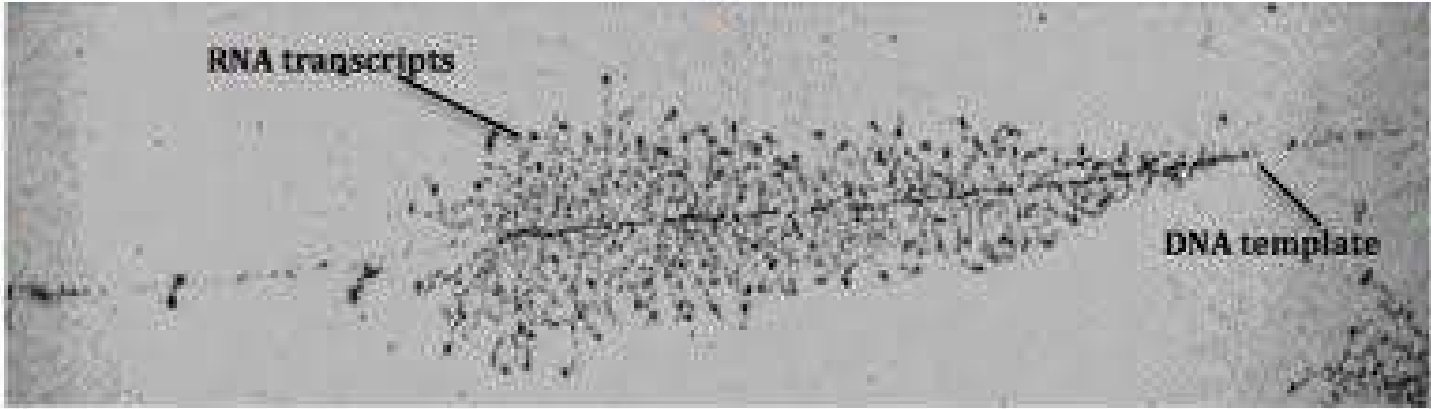
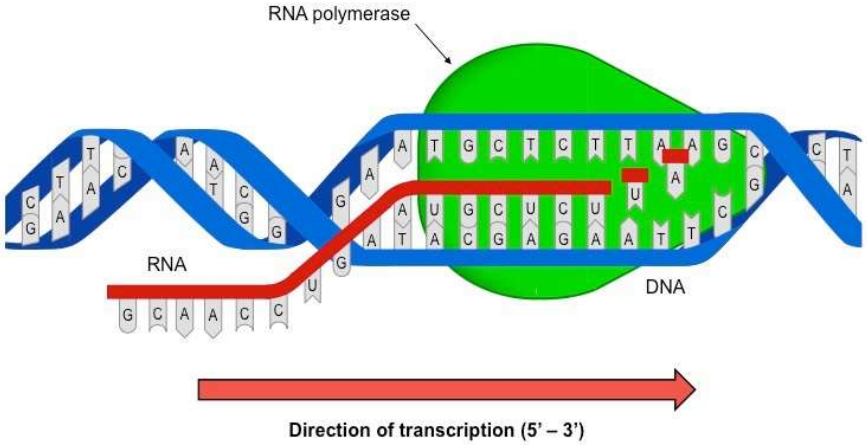
Structure of DNA



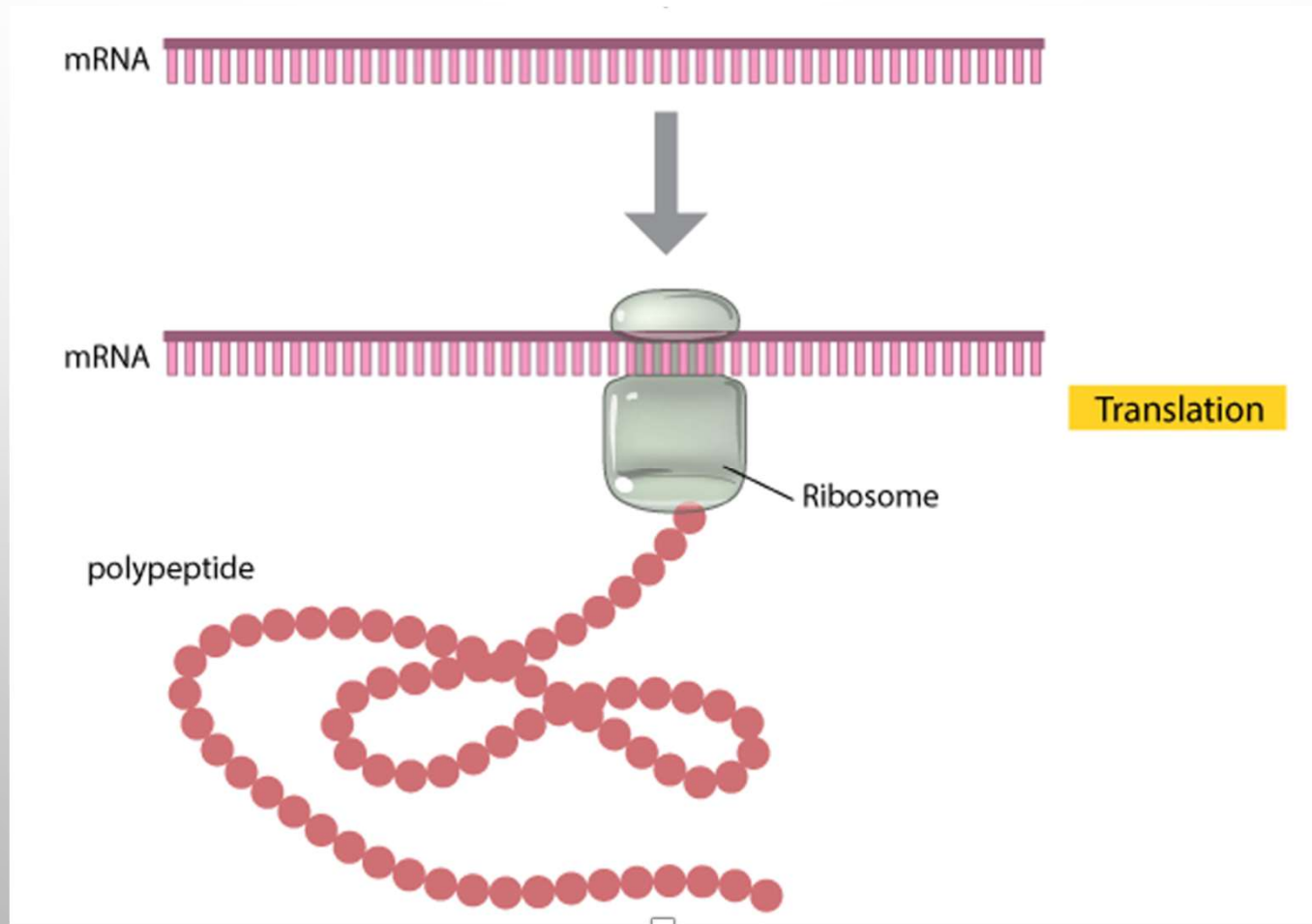
DNA REPLICATION



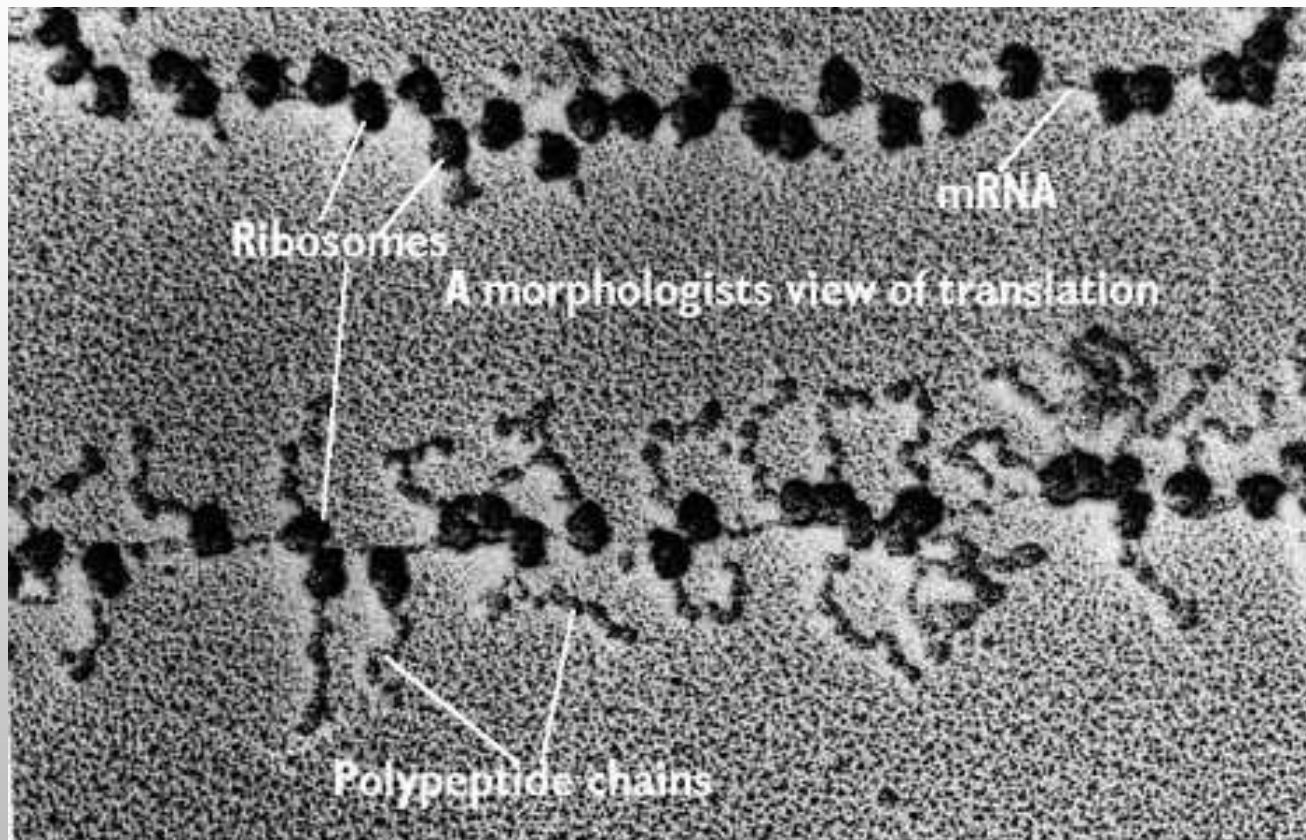
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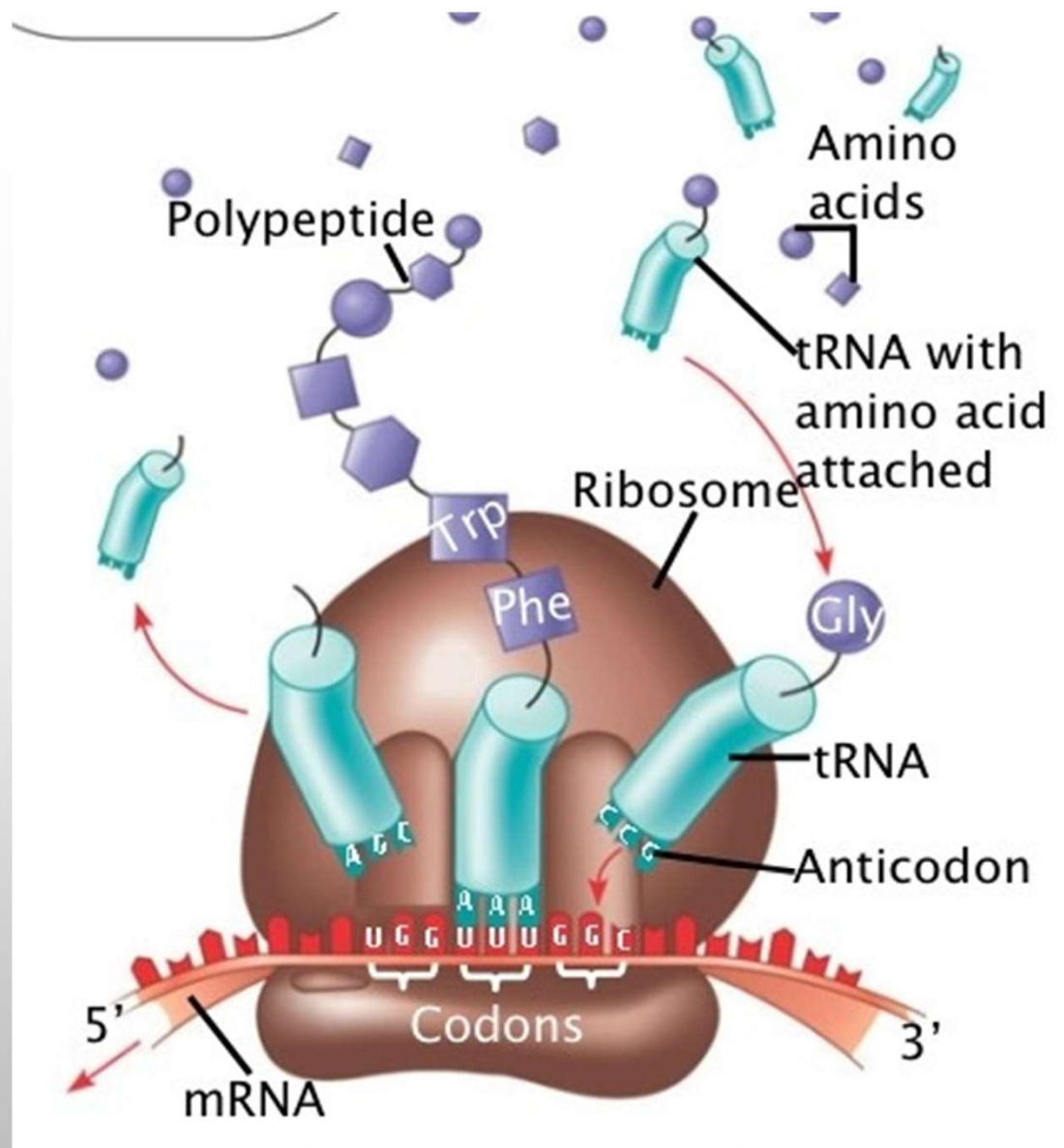


TRANSLATION



TRANSLATION





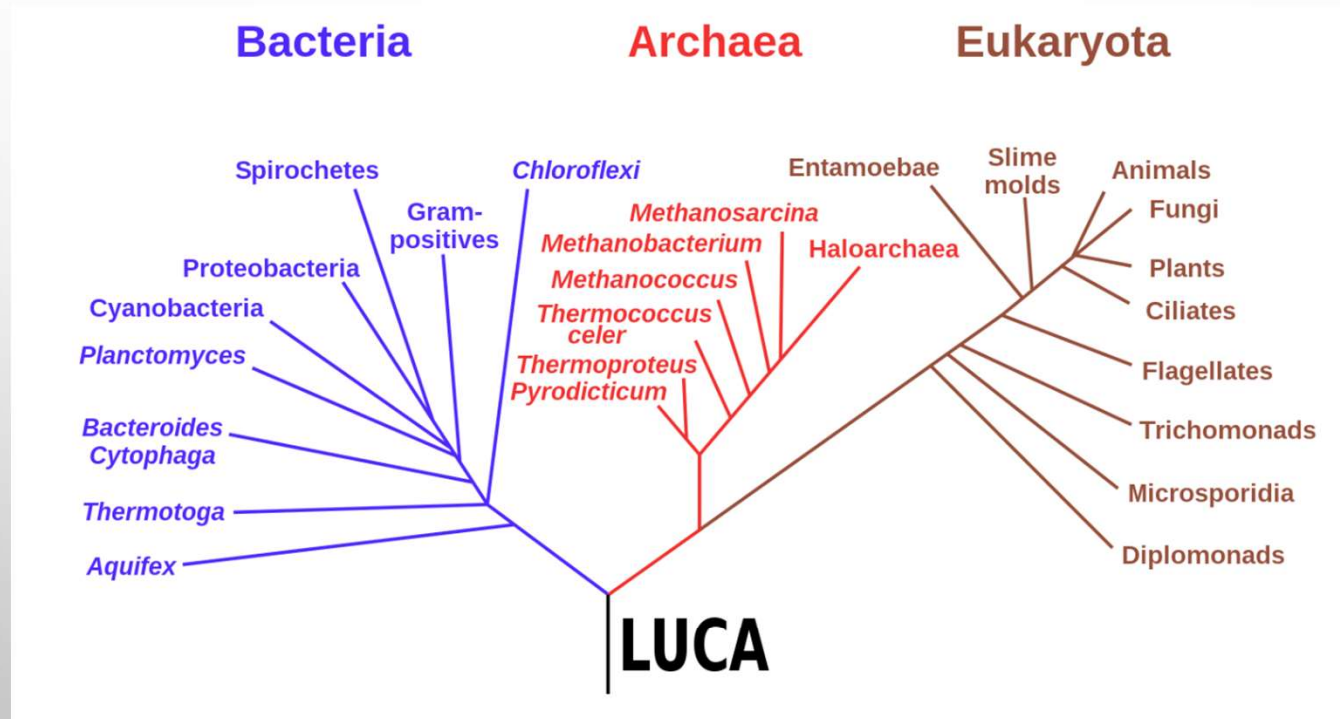


[HTTPS://WWW.YOUTUBE.COM/WATCH?V=CF777IBOGEG](https://www.youtube.com/watch?v=CF777IBOGEG)



- START WATCHING THE ANIMATION AT
- 1:01:26



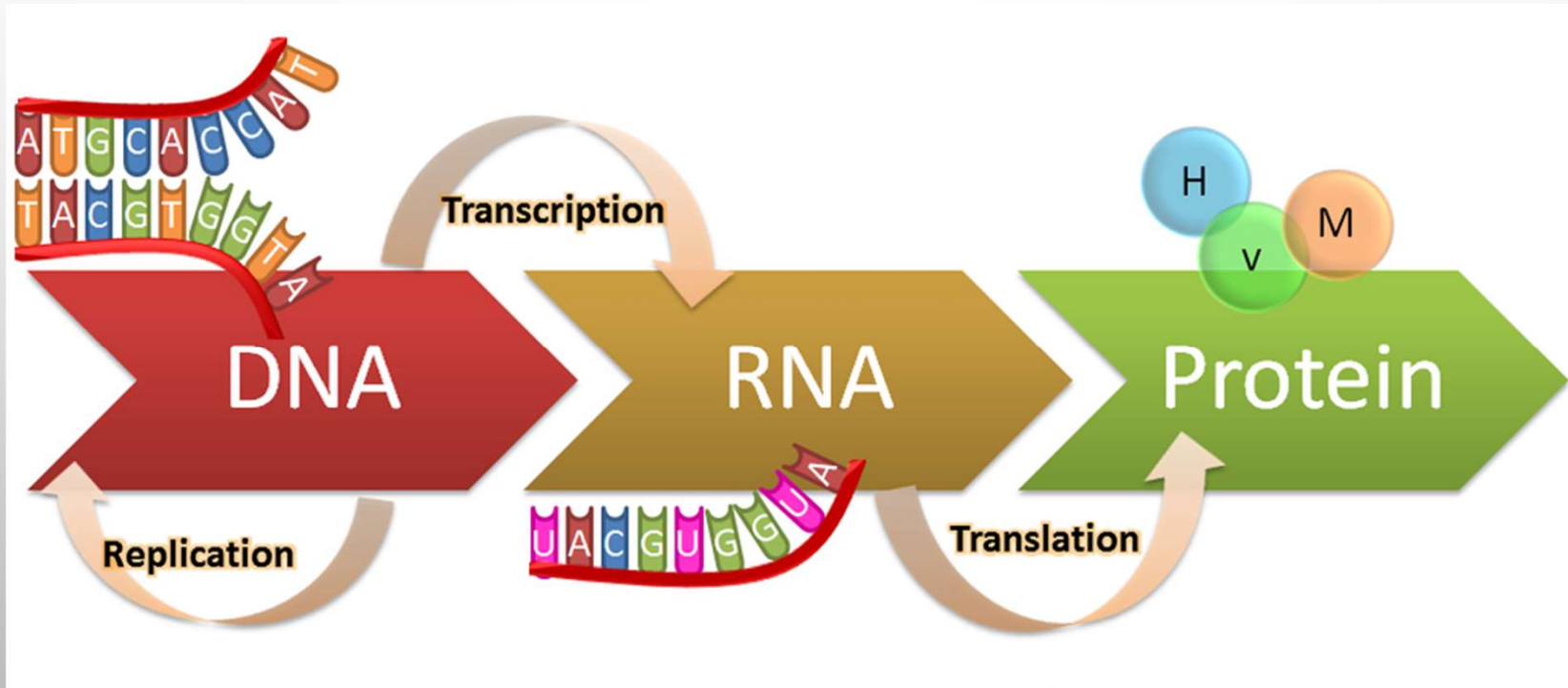
LIFE HISTORY



LUCA's Beginnings

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- LIFE IN THE TIME OF LUCA WAS ALMOST AS SOPHISTICATED AS LIFE NOW
 - IT HAD DNA, RNA, PROTEIN, A FULL PROTEIN-MAKING FACTORY (REAL RIBOSOMES: BETTER THAN HALF OF ALL RIBOSOMAL PROTEINS ARE UNIVERSAL)
 - THIS DID NOT SPRING FORTH FROM AN ABIOTIC WORLD. REMEMBER **NO MIRACLES ALLOWED**
 - HOW CAN WE SIMPLIFY ?
-
- **AND THIS IS WHERE THINGS GET REALLY INTERESTING...**
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THE INFORMATION HIGHWAY: FROM CODE TO CELLULAR FUNCTION



THE 1980'S: RNA RESEARCH COMES OF AGE: FROM "COAT HANGER" TO CATALYST



Tom Cech - U Colorado

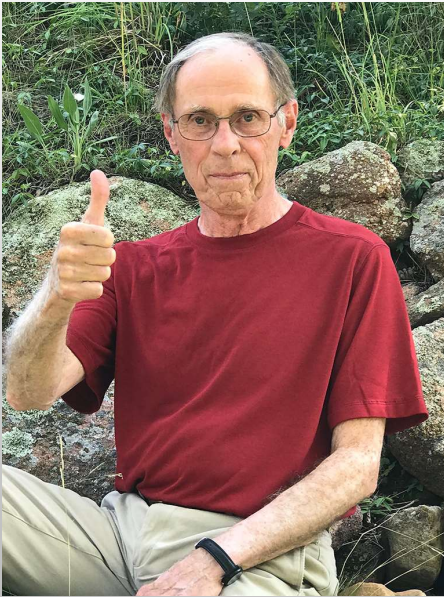


Sid Altman - Yale

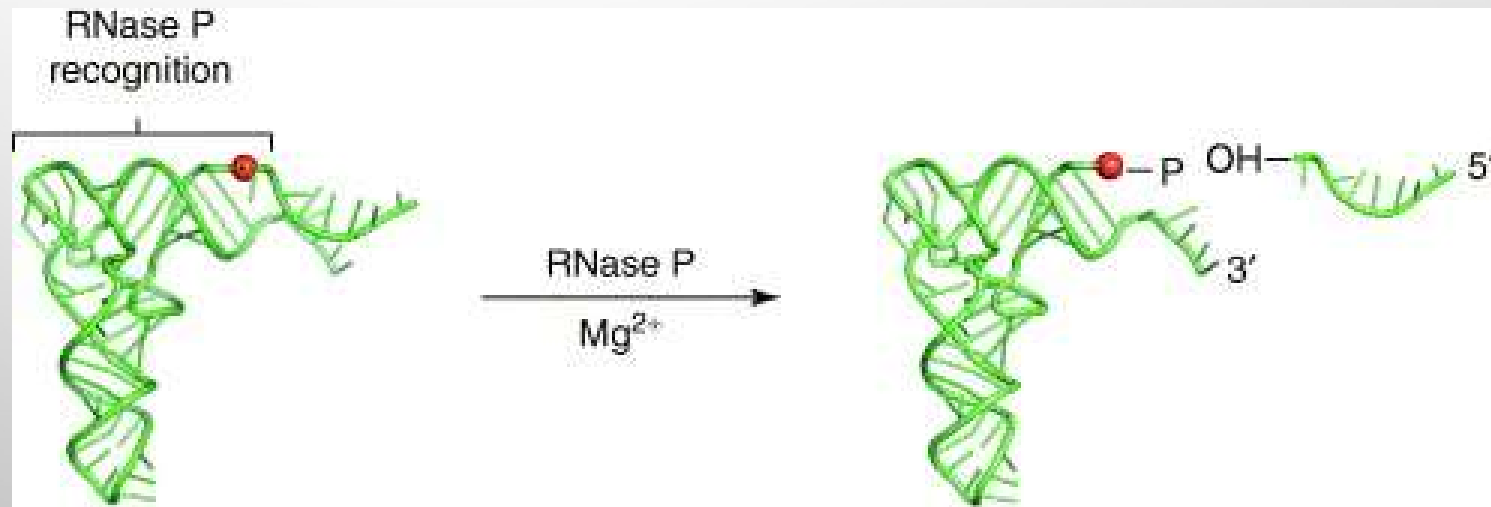
- RNA CAN BE AN EFFICIENT CATALYST
- IT CAN CATALYTICALLY CLEAVE ANOTHER RNA MOLECULE AT SPECIFIC SITES
- IT COMPLIES WITH ALL THE REQUIREMENTS OF A BIOLOGICAL CATALYST: IT IS NECESSARY FOR THE REACTION TO OCCUR; IT DOES NOT GET "CONSUMED" IN THE REACTION → IT CAN CATALYZE MULTIPLE ROUNDS OF CLEAVAGE
- NOBEL PRIZE 1989

FIRST RNA DISCOVERED TO BE AN ENZYME: A COLLABORATION BETWEEN ALTMAN (YALE) AND PACE (INDIANA U.) GROUPS

- THE RNA MOIETY OF RIBONUCLEASE P IS THE CATALYTIC SUBUNIT OF THE ENZYME
- C GERRIER-TAKADA, K GARDINER, T MARSH, N PACE, S ALTMAN - CELL, 1983




NORMAN PACE

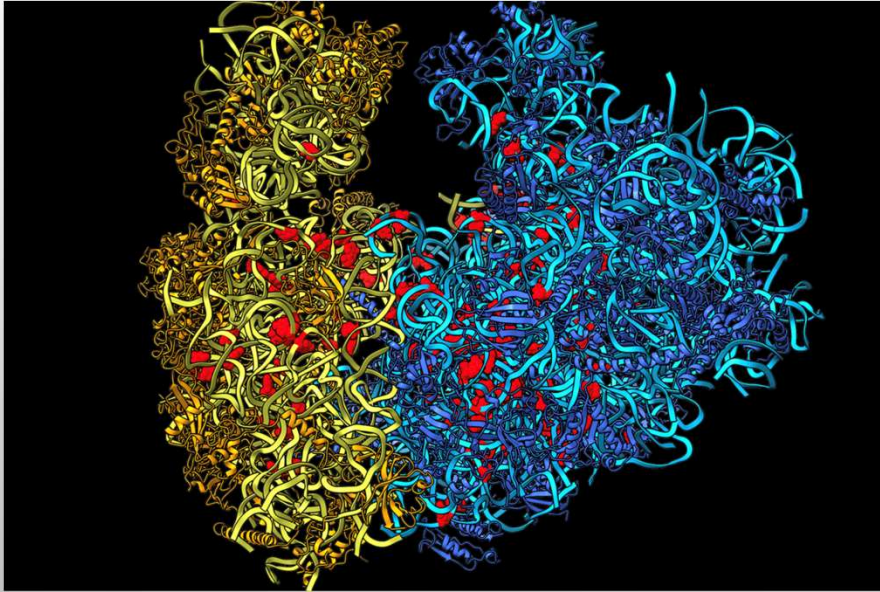




RNA AS FUNCTION

- IT CAN CLEAVE OTHER RNA MOLECULES AT SPECIFIC SITES
 - IT IS ESSENTIAL IN THE PROCESSING AND MATURATION OF OTHER RNA MOLECULES
 - IT IS INVOLVED IN THE MAINTENANCE OF TELOMERES
 - IT CAN REGULATE GENE EXPRESSION
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- **AND IT IS AT THE CENTER OF PROTEIN SYNTHESIS IN THE RIBOSOME**
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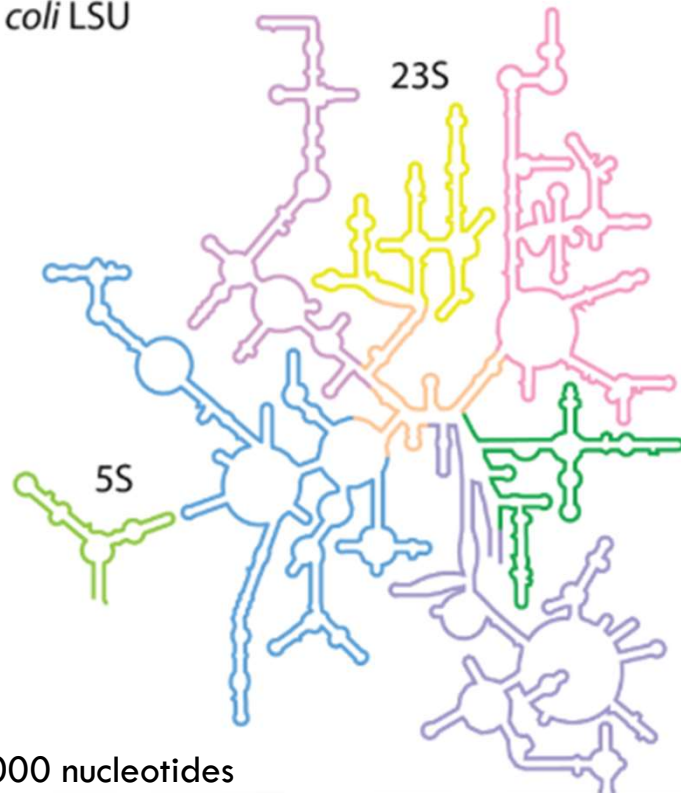
THE RIBOSOME



- THREE RIBOSOMAL RNAS
- OVER 50 (USUALLY PRETTY SMALL) RIBOSOMAL PROTEINS

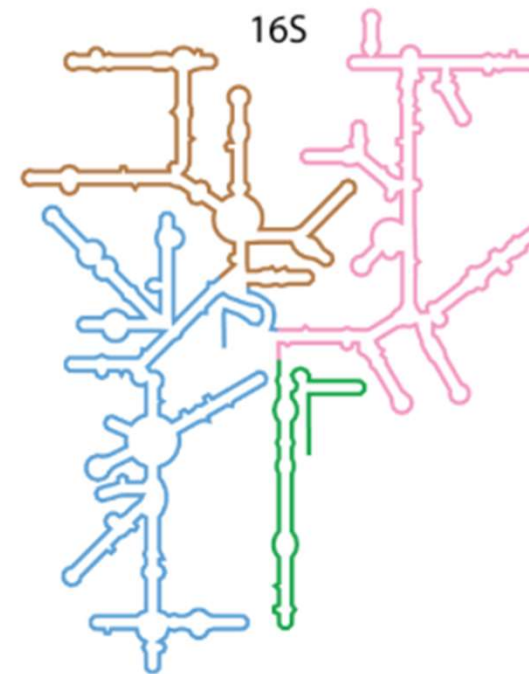
RIBOSOMAL RNAs (THE BIG ONES)

E. coli LSU



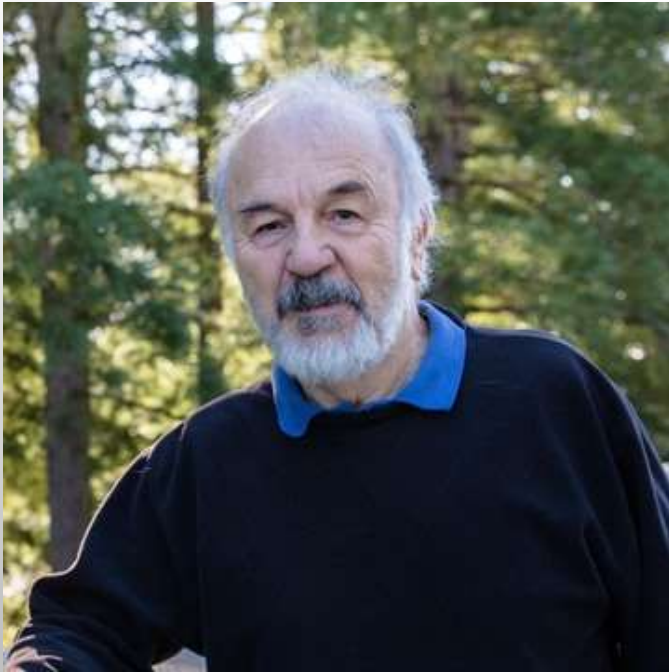
Ca. 3,000 nucleotides

E. coli SSU



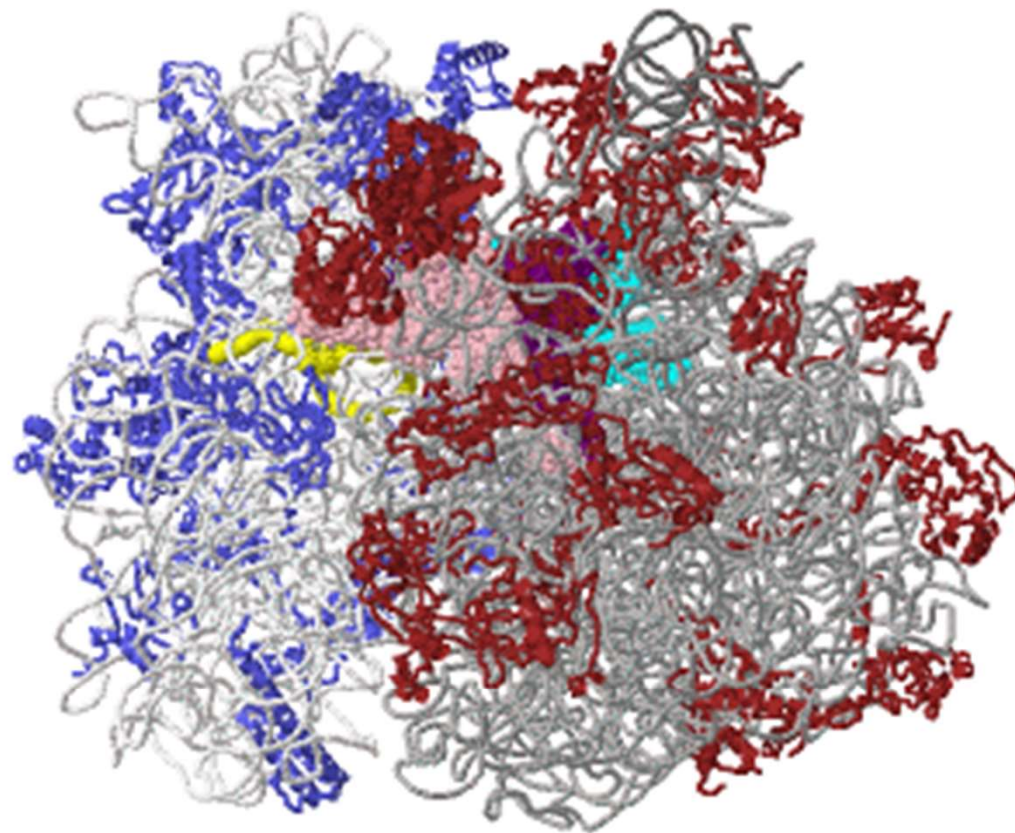
Ca. 1,500 nucleotides

REVEALING THE RIBOSOME: HARRY NOLLER'S ODYSSEY

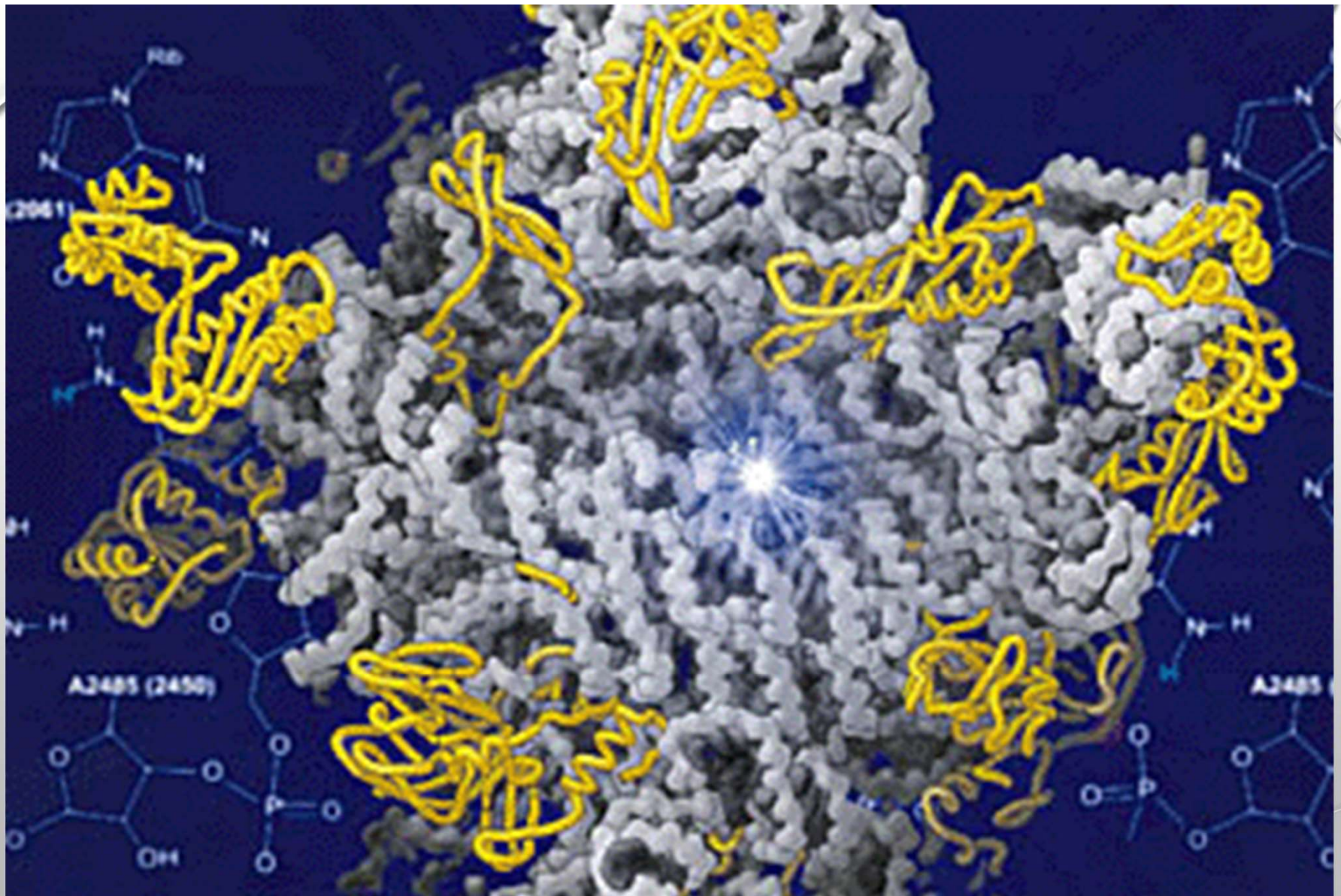


Harry Noller – UC Santa Cruz

- RIBOSOMES ARE COMPOSED OF 3 LARGE RNAS AND CA. 50, USUALLY SMALL, PROTEINS
- LIKE OTHER MOLECULAR BIOLOGISTS, HE ASSUMED THE PROTEINS WERE THE ACTIVE COMPONENTS
- HE SYSTEMATICALLY MODIFIED THE PROTEINS TO BLOCK THEIR ACTIVITY, AND FOUND THAT THE RIBOSOME CONTINUED TO FUNCTION WITHOUT THEM
- TREATING RIBOSOMES WITH A CHEMICAL THAT MODIFIES THE RNA KNOCKED OUT THE ACTIVITY OF THE RIBOSOME



Jmol



INSTITUTE FOR GENOMIC BIOLOGY – UIUC DARWIN'S PLAYGROUND



REMEMBER SESSION 1

- **MOLECULAR REQUIREMENTS FOR LIVING SYSTEMS:**
 - 1) MAINTAINING STRUCTURE → METABOLISM
 - 2) INFORMATION
 - 3) REPLICATION
- **ALL THE ABOVE FUNCTIONS (INFORMATION, REPLICATION AND METABOLISM) CAN BE ACCOMPLISHED BY RNA**
- **WELCOME TO THE “RNA WORLD”**
- **CAVEAT EMPTOR: THIS IS HYPOTHETICAL**