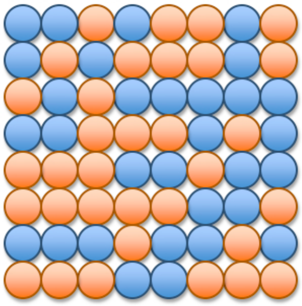
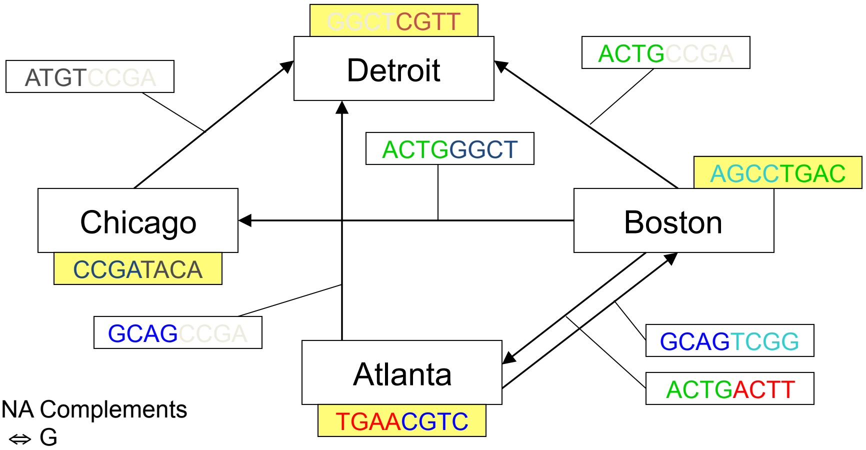


Epilogue:
The Future of Computing

DNA Computing

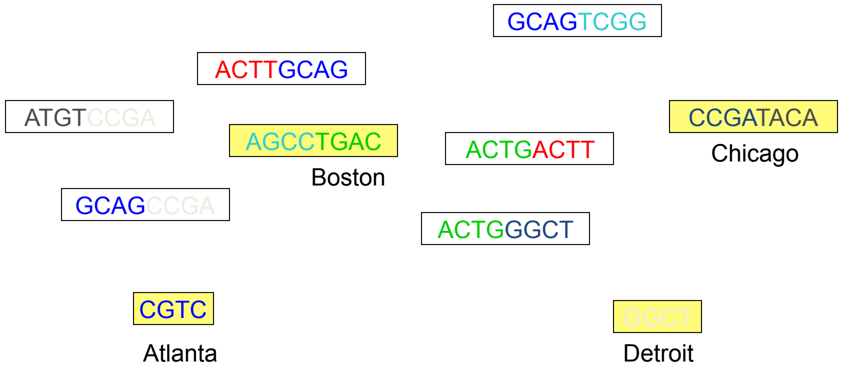
- Use of DNA strands to compute solutions quickly.
- Computing with DNA
  by Leonard Adleman (UC Berkeley)
  - Demonstrated the use of DNA to solve a small instance of the Hamiltonian path problem.
  - DNA sequences consist of the letters A,C,T,G representing the bases adenine, thymine, guanine, and cytosine.
- Adleman demonstrated the use of DNA to solve a Hamiltonian Path problem with 7 cities in 1998.
  - The Hamiltonian Path problem is NP Complete.

Example



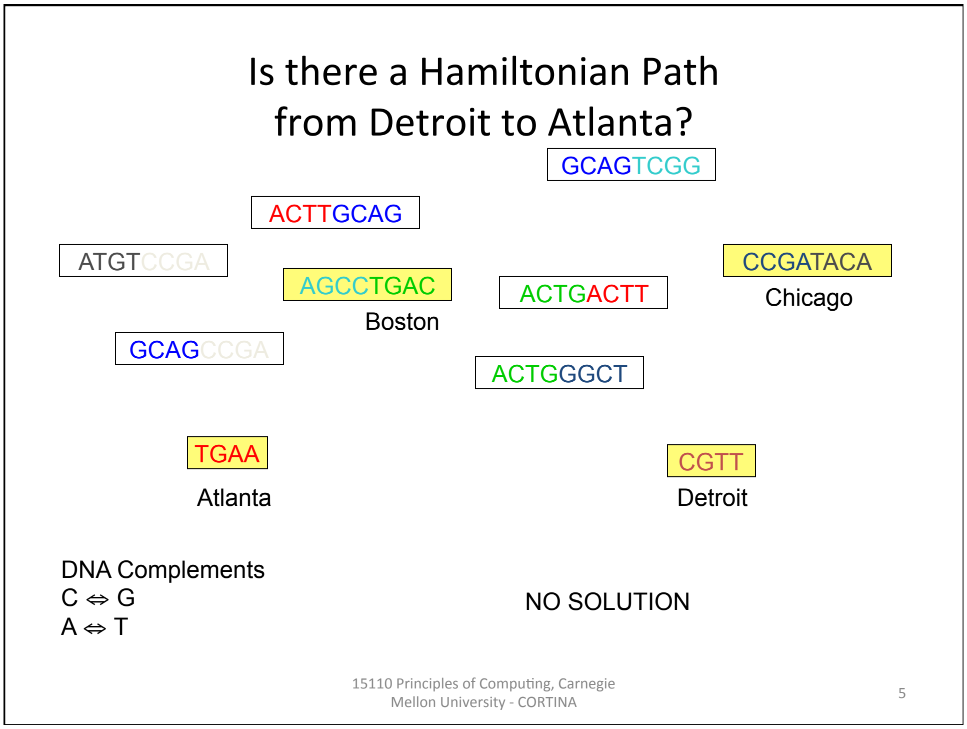
DNA Complements
C ⇔ G
A ⇔ T

Is there a Hamiltonian Path from Atlanta to Detroit?



DNA Complements
C ⇔ G
A ⇔ T

GCAG TCGG | ACTG GGCT | ATGT CCGA
CGTC | AGCC TGAC | CCGA TACA | GGCT



Is there a Hamiltonian Path from Detroit to Atlanta?

GCAGTCGG

ACTTGCAG

ATGTCCGA

AGCCTGAC
Boston

ACTGACTT

CCGATACA
Chicago

GCAGCCGA

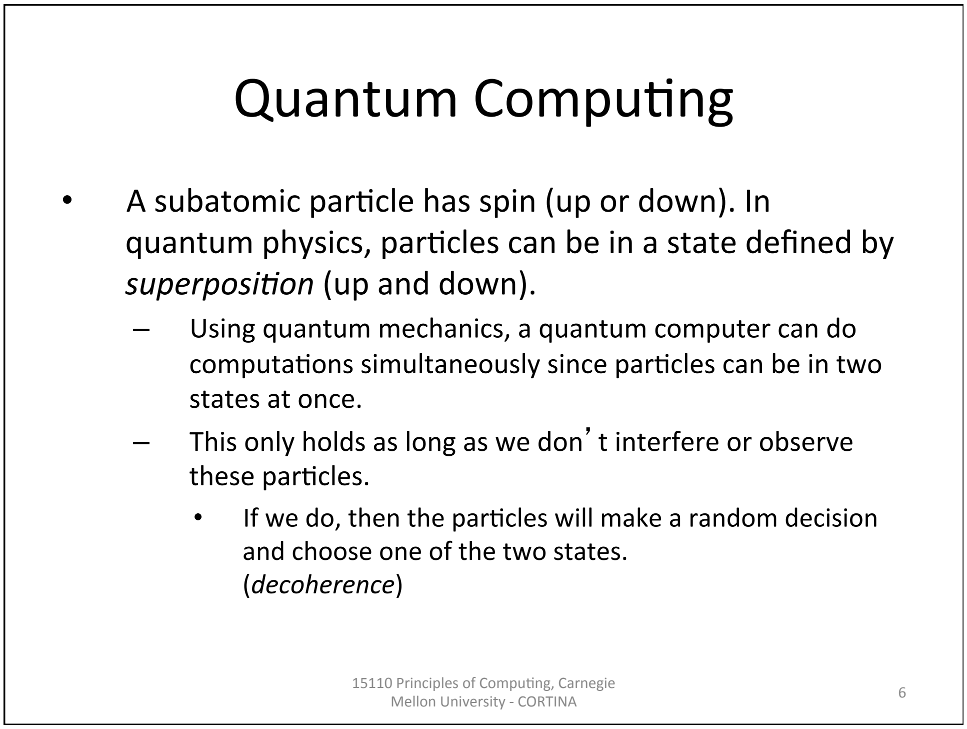
ACTGGGCT

TGAA
Atlanta

CGTT
Detroit

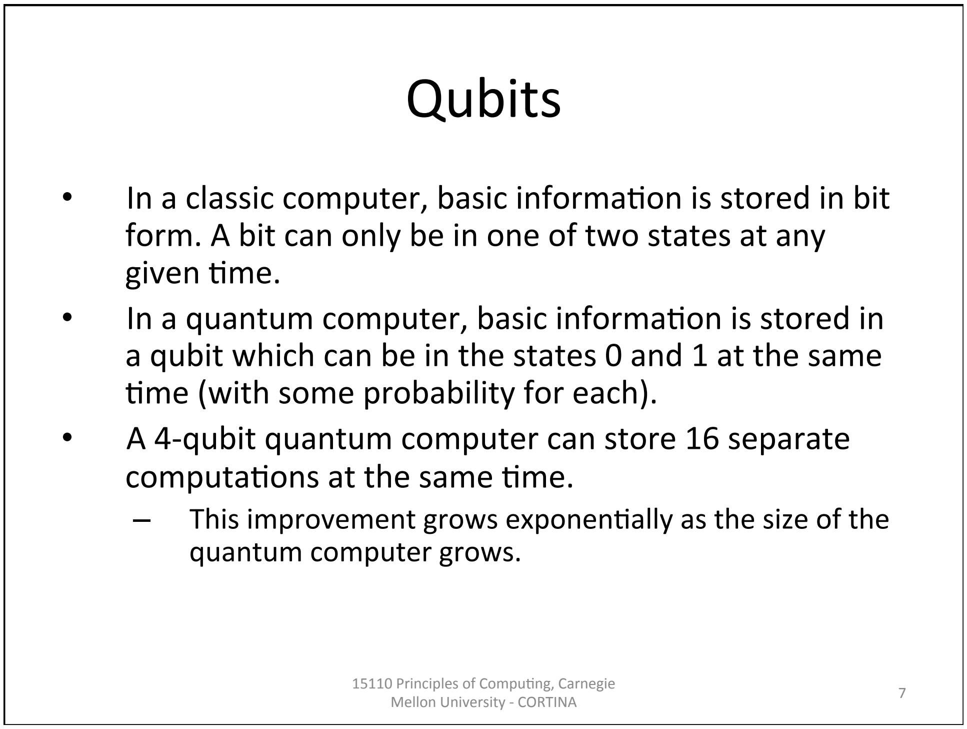
DNA Complements
C ⇔ G
A ⇔ T

NO SOLUTION



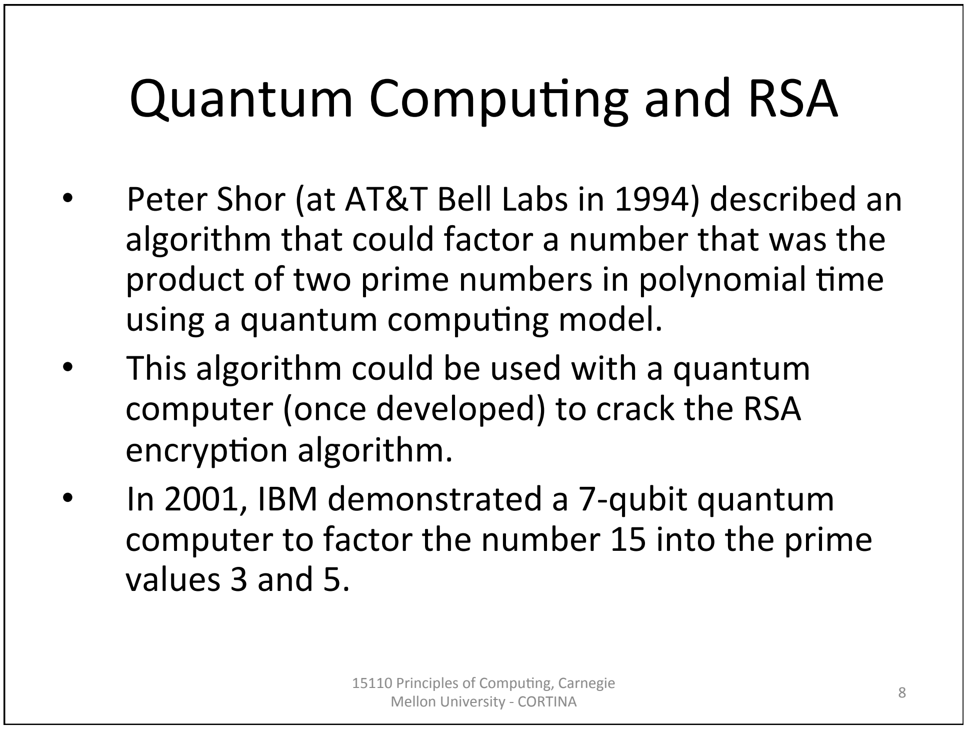
Quantum Computing

- A subatomic particle has spin (up or down). In quantum physics, particles can be in a state defined by *superposition* (up and down).
  - Using quantum mechanics, a quantum computer can do computations simultaneously since particles can be in two states at once.
  - This only holds as long as we don't interfere or observe these particles.
    - If we do, then the particles will make a random decision and choose one of the two states. (*decoherence*)



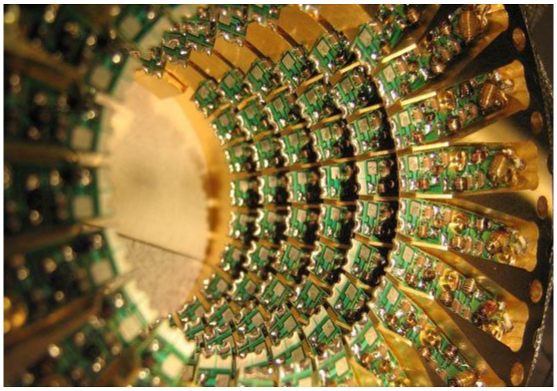
Qubits

- In a classic computer, basic information is stored in bit form. A bit can only be in one of two states at any given time.
- In a quantum computer, basic information is stored in a qubit which can be in the states 0 and 1 at the same time (with some probability for each).
- A 4-qubit quantum computer can store 16 separate computations at the same time.
  - This improvement grows exponentially as the size of the quantum computer grows.



Quantum Computing and RSA

- Peter Shor (at AT&T Bell Labs in 1994) described an algorithm that could factor a number that was the product of two prime numbers in polynomial time using a quantum computing model.
- This algorithm could be used with a quantum computer (once developed) to crack the RSA encryption algorithm.
- In 2001, IBM demonstrated a 7-qubit quantum computer to factor the number 15 into the prime values 3 and 5.



D-Wave Systems “demonstrated”
a 28-qubit quantum computer
in November 2007 at a SC07
(a supercomputing conference).

What’s Next?

- Will we eventually prove that P = NP or P ≠ NP?
- Will the computers for the next generation be made up of DNA or quantum particles rather than silicon?
- Will robots eventually replace humans as the dominant race due to their superior intelligence?
- Will humans become more and more robotic as they evolve?