

YOUR TITLE GOES HERE

By

CHRISTIAN LOER T. LLEMIT

A thesis submitted in partial fulfillment of
the requirements for the degree of

BACHELOR OF SCIENCE

UNIVERSITY OF THE PHILIPPINES - DILIMAN
National Institute of Physics

FEBRUARY 2020

© Copyright by CHRISTIAN LOER T. LLEMIT, 2020
All Rights Reserved

To the Faculty of Washington State University:

The members of the Committee appointed to examine the thesis of CHRISTIAN LOER
T. LLEMIT find it satisfactory and recommend that it be accepted.

Rudyard Kipling, Ph.D., Chair

Jane Austin, Ph.D.

John F. Kennedy, Ph.D.

ACKNOWLEDGMENT

Nullam mollis et leo at pharetra. Nulla efficitur molestie euismod. Sed dapibus metus sed tempus varius. Aenean finibus eros ut urna luctus feugiat. Duis turpis risus, viverra vitae porta et, ullamcorper ac est. Proin in eros nec ipsum interdum tempus. Nam fringilla lectus velit, non posuere ex vehicula ut. Mauris tincidunt, dolor sit amet commodo tempor, erat mi egestas dui, at elementum tellus est rhoncus libero. Ut et rutrum lectus, id viverra tortor. Vivamus nec lacus eros. Donec dictum porta nisi et vestibulum. Mauris luctus ligula ut libero aliquet luctus. Quisque malesuada egestas finibus.

Mauris dictum pharetra fermentum. Maecenas ut felis varius, dapibus sapien imperdiet, dictum dui. Proin feugiat viverra metus non laoreet. Integer pulvinar mi id lacus semper commodo. Praesent vel erat interdum purus scelerisque maximus. Sed enim risus, mollis blandit ligula ac, sagittis venenatis augue. Mauris nisi purus, gravida ac aliquam eu, ullamcorper eget nulla. Proin id finibus purus. Vestibulum leo ante, porta in quam sed, eleifend feugiat arcu. Nunc viverra fringilla turpis a iaculis. In condimentum aliquet mauris, quis laoreet eros porta eu. Aenean ut turpis a massa gravida pretium. Phasellus auctor purus quis diam interdum, nec luctus lorem auctor. Pellentesque finibus elit justo, a vulputate diam fermentum lacinia.

YOUR TITLE GOES HERE

Abstract

by Christian Loer T. Llemit, Ph.D.
University of the Philippines - Diliman
February 2020

: Rudyard Kipling

Nullam mollis et leo at pharetra. Nulla efficitur molestie euismod. Sed dapibus metus sed tempus varius. Aenean finibus eros ut urna luctus feugiat. Duis turpis risus, viverra vitae porta et, ullamcorper ac est. Proin in eros nec ipsum interdum tempus. Nam fringilla lectus velit, non posuere ex vehicula ut. Mauris tincidunt, dolor sit amet commodo tempor, erat mi egestas dui, at elementum tellus est rhoncus libero. Ut et rutrum lectus, id viverra tortor. Vivamus nec lacus eros. Donec dictum porta nisi et vestibulum. Mauris luctus ligula ut libero aliquet luctus. Quisque malesuada egestas finibus.

Mauris dictum pharetra fermentum. Maecenas ut felis varius, dapibus sapien imperdiet, dictum dui. Proin feugiat viverra metus non laoreet. Integer pulvinar mi id lacus semper commodo. Praesent vel erat interdum purus scelerisque maximus. Sed enim risus, mollis blandit ligula ac, sagittis venenatis augue. Mauris nisi purus, gravida ac aliquam eu, ullamcorper eget nulla. Proin id finibus purus. Vestibulum leo ante, porta in quam sed, eleifend feugiat arcu.

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENT	iii
ABSTRACT	iv
LIST OF TABLES	ix
LIST OF FIGURES	x
1 INTRODUCTION	1
1.1 Semiconductors	1
1.2 Applications of Semiconductors	1
1.3 Defects in Semiconductors	1
1.4 ZnO	1
1.4.1 Subsection of section - double quotes	1
1.4.2 Another subsection of section - citations	2
1.4.2.1 Subsubsection of section - italic text	2
2 THEORETICAL FRAMEWORK	4
2.1 Many-body Quantum Mechanics	4
2.1.1 Simplifying Assumptions	6
2.1.2 Time Independent Schrödinger Equation	6
2.1.3 Use of Atomic Units	6
2.1.4 Hamiltonian Operator	6
2.1.5 Indistinguishability of electrons	6
2.2 Early First Principle Calculations	6
2.2.1 n-electron problem	6
2.2.2 Hartree Method	6
2.2.3 Hartree-Fock Method	6

2.3	Density Functional Theory	6
2.3.1	Electron Density	6
2.3.2	Hohenberg-Kohn (HK) Formalism	6
2.3.2.1	First HK Theorem	6
2.3.2.2	Second HK Theorem	6
2.3.3	Kohn Sham (KS) Formalism	6
2.3.3.1	KS Equation	6
2.3.3.2	Energy Terms	6
2.4	Exchange-correlation Functional	6
2.4.1	Local Density Approximation (LDA)	6
2.4.2	Generalized Gradient Approximation (GGA)	6
3	DFT Calculation of Solids	7
3.1	Pseudopotential Approach	7
3.1.1	Freezing the core electrons	8
3.1.2	Pseudizing the valence electrons	8
3.1.3	Common Pseudopotentials	8
3.2	Choosing the appropriate Calculation Size	8
3.2.1	Use of Supercell	8
3.2.1.1	Periodic Boundary Conditions (PBC)	8
3.2.2	Use of Reciprocal Space	8
3.2.2.1	Reciprocal Lattice	8
3.2.2.2	First Brillouin Zone	8
3.2.2.3	Irreducible Brillouin Zone	8
3.2.3	k-point sampling	8
3.2.3.1	Monkhorst-Pack method	8
3.2.3.2	Gamma Point Sampling	8
3.3	Bloch Representations	10
3.3.1	Electrons in solid	10
3.3.2	Bloch Theorem in periodic systems	10
3.3.3	Fourier Expansion of Bloch representations	10
3.3.3.1	Fourier Expansions	10

3.3.3.2	Fast Fourier Transformation (FFT)	10
3.3.3.3	Kohn-Sham Matrix Representations	10
3.4	Plane Wave (PW) Expansion	10
3.4.1	Basis Set	10
3.4.1.1	Local Basis Set	10
3.4.1.2	Plane Wave Basis Set	10
3.4.2	Plane Wave Expansion for KS quantities	10
3.4.2.1	Charge Density	10
3.4.2.2	Kinetic Energy	10
3.4.2.3	Effective Potential	10
3.5	Electronic Structure	10
3.5.1	Band Structure of free electrons	10
3.5.2	Band Structure of electrons in solids	10
3.5.3	Electronic Density of States	10
3.6	Practical Aspects	10
3.6.1	Energy Cutoffs	10
3.6.1.1	Cutoff for Wavefunction	10
3.6.1.2	Cutoff for Charge Density	10
3.6.2	Smearing	10
3.6.2.1	Gaussian Smearing	10
3.6.2.2	Fermi Smearing	10
3.6.2.3	Methfessel–Paxton Smearing	10
3.6.2.4		10
4	MATHEMATICS NOTATION	11
4.1	Some Math Stuff	11
4.2	Math equation	12
4.3	Chapter section	12
4.4	Chapter section	13
5	FIGURES AND TABLES	14
5.1	Examples of a figure	14

5.2	Example of a table	15
5.3	Chapter section	16
REFERENCES		18
APPENDIX		
A	. . . . .	20
B	. . . . .	22
C	. . . . .	23
D	. . . . .	24
E	. . . . .	25

LIST OF TABLES

5.1	Whole-genome sequences used in this study	16
-----	---	----

LIST OF FIGURES

5.1	Cost per raw megabase of DNA sequence from 2001 to 2015	15
A.1	Cost per raw megabase of DNA sequence from 2001 to 2015	20
A.2	Cost per raw megabase of DNA sequence from 2001 to 2015	21
B.1	Cost per raw megabase of DNA sequence from 2001 to 2015	22
C.1	Cost per raw megabase of DNA sequence from 2001 to 2015	23
D.1	Cost per raw megabase of DNA sequence from 2001 to 2015	24
E.1	Cost per raw megabase of DNA sequence from 2001 to 2015	25

Dedication

This dissertation/thesis is dedicated to my mother and father who
provided both emotional and financial support

Chapter One

INTRODUCTION

1.1 Semiconductors

1.2 Applications of Semiconductors

1.3 Defects in Semiconductors

1.4 ZnO

This is an example of how to cite [\[1\]](#)

1.4.1 Subsection of section - double quotes

Example of double quotes “word”. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Curabitur viverra, velit eget vestibulum viverra, nisl eros aliquet sapien, sed interdum tellus justo et purus. Nulla vel orci nisl. Curabitur porta lacinia quam, finibus bibendum mi tincidunt eget. Aenean aliquam lobortis orci, ut aliquam neque imperdiet vel. Nunc sit amet scelerisque velit. Aenean quis tempor leo, at consectetur ipsum. Nam ac urna dapibus, condimentum orci a, ornare ante. In hac habitasse platea dictumst. [\[2\]](#)

1.4.2 Another subsection of section - citations

Example of citation [3]. Mauris nisi felis, pharetra vitae velit at, sollicitudin molestie justo. Aenean tristique diam pulvinar, semper risus sed, mattis elit. Phasellus interdum erat at enim maximus interdum. Curabitur tempor, arcu nec malesuada facilisis, tortor nisi ornare ex, ut porttitor elit lectus aliquam diam. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Vivamus quam turpis, auctor in nunc nec, varius pharetra nibh. Ut sagittis diam nec dui sodales tempor. Integer molestie diam id quam placerat eleifend. Nulla posuere iaculis nisi, et sagittis ipsum consequat scelerisque. In nec turpis eget tellus pulvinar porttitor vitae ac tortor. Nullam tempor ut orci ac porttitor. Pellentesque aliquam lacinia gravida. Duis accumsan tristique augue, vitae aliquam magna convallis ac. Aenean vel diam non eros venenatis ullamcorper sit amet at augue.

Example of multiple citations [3, 4]. Nullam mollis et leo at pharetra. Nulla efficitur molestie euismod. Sed dapibus metus sed tempus varius. Aenean finibus eros ut urna luctus feugiat. Duis turpis risus, viverra vitae porta et, ullamcorper ac est. Proin in eros nec ipsum interdum tempus. Nam fringilla lectus velit, non posuere ex vehicula ut. Mauris tincidunt, dolor sit amet commodo tempor, erat mi egestas dui, at elementum tellus est rhoncus libero. Ut et rutrum lectus, id viverra tortor. Vivamus nec lacus eros. Donec dictum porta nisi et vestibulum. Mauris luctus ligula ut libero aliquet luctus. Quisque malesuada egestas finibus.

1.4.2.1 Subsubsection of section - italic text

Example of italic text - *Escherichia*, *Salmonella*, and *Shigella* spp. Mauris dictum pharetra fermentum. Maecenas ut felis varius, dapibus sapien imperdiet, dictum dui. Proin feugiat viverra metus non laoreet. Integer pulvinar mi id lacus semper commodo. Praesent vel erat interdum purus scelerisque maximus. Sed enim risus, mollis blandit ligula ac, sagittis venenatis augue. Mauris nisi purus, gravida ac aliquam eu, ullamcorper eget nulla. Proin id finibus purus. Vestibulum leo ante, porta in quam sed, eleifend feugiat arcu. Nunc viverra

fringilla turpis a iaculis. In condimentum aliquet mauris, quis laoreet eros porta eu. Aenean
ut turpis a massa gravida pretium. Phasellus auctor purus quis diam interdum, nec luctus
lorem auctor. Pellentesque finibus elit justo, a vulputate diam fermentum lacinia.

Chapter Two

THEORETICAL FRAMEWORK

2.1 Many-body Quantum Mechanics

insert text here

2.1.1 Simplifying Assumptions

2.1.2 Time Independent Schrödinger Equation

2.1.3 Use of Atomic Units

2.1.4 Hamiltonian Operator

2.1.5 Indistinguishability of electrons

2.2 Early First Principle Calculations

2.2.1 n-electron problem

2.2.2 Hartree Method

2.2.3 Hartree-Fock Method

2.3 Density Functional Theory

2.3.1 Electron Density

2.3.2 Hohenberg-Kohn (HK) Formalism

2.3.2.1 First HK Theorem

2.3.2.2 Second HK Theorem

2.3.3 Kohn Sham (KS) Formalism

2.3.3.1 KS Equation

2.3.3.2 Energy Terms

2.4 Exchange-correlation Functional

2.4.1 Local Density Approximation (LDA)

Chapter Three

DFT Calculation of Solids

3.1 Pseudopotential Approach

This is sample text

3.1.1 Freezing the core electrons

3.1.2 Pseudizing the valence electrons

3.1.3 Common Pseudopotentials

3.2 Choosing the appropriate Calculation Size

3.2.1 Use of Supercell

3.2.1.1 Periodic Boundary Conditions (PBC)

3.2.2 Use of Reciprocal Space

3.2.2.1 Reciprocal Lattice

3.2.2.2 First Brillouin Zone

3.2.2.3 Irreducible Brillouin Zone

3.2.3 k-point sampling

3.2.3.1 Monkhorst-Pack method

3.2.3.2 Gamma Point Sampling

Example of double quotes “word”. Lore

3.3 Bloch Representations

3.3.1 Electrons in solid

3.3.2 Bloch Theorem in periodic systems

3.3.3 Fourier Expansion of Bloch representations

3.3.3.1 Fourier Expansions

3.3.3.2 Fast Fourier Transformation (FFT)

3.3.3.3 Kohn-Sham Matrix Representations

3.4 Plane Wave (PW) Expansion

3.4.1 Basis Set

3.4.1.1 Local Basis Set

3.4.1.2 Plane Wave Basis Set

3.4.2 Plane Wave Expansion for KS quantities

3.4.2.1 Charge Density

3.4.2.2 Kinetic Energy

3.4.2.3 Effective Potential

3.5 Electronic Structure

3.5.1 Band Structure of free electrons

3.5.2 Band Structure of electrons in solids

3.5.3 Electronic Density of States

3.6 Practical Aspects

Chapter Four

MATHEMATICS NOTATION

4.1 Some Math Stuff

LaTeX has a special way to embed mathematical symbols and notations. Here are some of them. Also observe how a bullet list is made.

- greater than \geq
- less than \leq
- percent sign %
- multiply $N \times N$
- inline equation $M = N(N - 1)/2$

Sed orci justo, rutrum in dolor a, consequat dictum mi. Sed luctus congue ex nec dignissim. Phasellus volutpat urna vestibulum ipsum vestibulum, quis venenatis justo consectetur. Nullam hendrerit nisl in rutrum convallis. Sed sit amet malesuada nisi. Phasellus dolor neque, vehicula vestibulum semper at, facilisis eget libero. Mauris interdum magna molestie, auctor felis a, condimentum odio. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Suspendisse maximus lacinia dignissim. Maecenas pharetra accumsan metus, sagittis dictum purus sollicitudin eget. Curabitur ut porttitor arcu, ut porttitor ipsum. Vestibulum porttitor finibus sapien, ac pharetra odio bibendum nec. Nullam tincidunt dignissim risus imperdiet dictum.

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Suspendisse maximus lacinia dignissim. Maecenas pharetra accumsan metus, sagittis dictum purus sollicitudin eget. Curabitur ut porttitor arcu, ut porttitor ipsum. Vestibulum porttitor finibus sapien, ac pharetra odio bibendum nec. Nullam tincidunt dignissim risus imperdiet dictum.

4.2 Math equation

Example of a mathematical formula:

$$ADD = \sum_{i=1}^M | < D(n+1, i) > - < D(n, i) > | \quad (4.1)$$

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Suspendisse maximus lacinia dignissim. Maecenas pharetra accumsan metus, sagittis dictum purus sollicitudin eget. Curabitur ut porttitor arcu, ut porttitor ipsum. Vestibulum porttitor finibus sapien, ac pharetra odio bibendum nec. Nullam tincidunt dignissim risus imperdiet dictum.

4.3 Chapter section

Fusce ultricies pulvinar diam sed ultrices. Sed orci justo, rutrum in dolor a, consequat dictum mi. Sed luctus congue ex nec dignissim. Phasellus volutpat urna vestibulum ipsum vestibulum, quis venenatis justo consectetur. Nullam hendrerit nisl in rutrum convallis. Sed sit amet malesuada nisi. Phasellus dolor neque, vehicula vestibulum semper at, facilisis eget libero. Mauris interdum magna molestie, auctor felis a, condimentum odio. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Suspendisse maximus lacinia dignissim. Maecenas pharetra accumsan metus, sagittis dictum purus sollicitudin eget. Curabitur ut porttitor arcu, ut porttitor ipsum. Vestibulum porttitor finibus sapien, ac pharetra odio bibendum nec. Nullam tincidunt dignissim risus imperdiet dictum.

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Suspendisse maximus lacinia dignissim. Maecenas pharetra accumsan metus, sagittis dictum purus sollicitudin eget. Curabitur ut porttitor arcu, ut porttitor ipsum. Vestibulum porttitor finibus sapien, ac pharetra odio bibendum nec. Nullam tincidunt dignissim risus imperdiet dictum.

4.4 Chapter section

Fusce ultricies pulvinar diam sed ultrices. Sed orci justo, rutrum in dolor a, consequat dictum mi. Sed luctus congue ex nec dignissim. Phasellus volutpat urna vestibulum ipsum vestibulum, quis venenatis justo consectetur. Nullam hendrerit nisl in rutrum convallis. Sed sit amet malesuada nisi. Phasellus dolor neque, vehicula vestibulum semper at, facilisis eget libero. Mauris interdum magna molestie, auctor felis a, condimentum odio. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Suspendisse maximus lacinia dignissim. Maecenas pharetra accumsan metus, sagittis dictum purus sollicitudin eget. Curabitur ut porttitor arcu, ut porttitor ipsum. Vestibulum porttitor finibus sapien, ac pharetra odio bibendum nec. Nullam tincidunt dignissim risus imperdiet dictum.

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Suspendisse maximus lacinia dignissim. Maecenas pharetra accumsan metus, sagittis dictum purus sollicitudin eget. Curabitur ut porttitor arcu, ut porttitor ipsum. Vestibulum porttitor finibus sapien, ac pharetra odio bibendum nec. Nullam tincidunt dignissim risus imperdiet dictum.

Chapter Five

FIGURES AND TABLES

5.1 Examples of a figure

Fusce ultricies pulvinar diam sed ultrices. Sed orci justo, rutrum in dolor a, consequat dictum mi. Sed luctus congue ex nec dignissim. Phasellus volutpat urna vestibulum ipsum vestibulum, quis venenatis justo consectetur. Nullam hendrerit nisl in rutrum convallis. Sed sit amet malesuada nisi.

Example of a figure. Example of reference to a figure in the text (Fig. 5.1). Phasellus dolor neque, vehicula vestibulum semper at, facilisis eget libero. Mauris interdum magna molestie, auctor felis a, condimentum odio. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Suspendisse maximus lacinia dignissim. Maecenas pharetra accumsan metus, sagittis dictum purus sollicitudin eget. Curabitur ut porttitor arcu, ut porttitor ipsum. Vestibulum porttitor finibus sapien, ac pharetra odio bibendum nec. Nullam tincidunt dignissim risus imperdiet dictum.

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Suspendisse maximus lacinia dignissim. Maecenas pharetra accumsan metus, sagittis dictum purus sollicitudin eget. Curabitur ut porttitor arcu, ut porttitor ipsum. Vestibulum porttitor finibus sapien, ac pharetra odio bibendum nec. Nullam tincidunt dignissim risus imperdiet dictum.

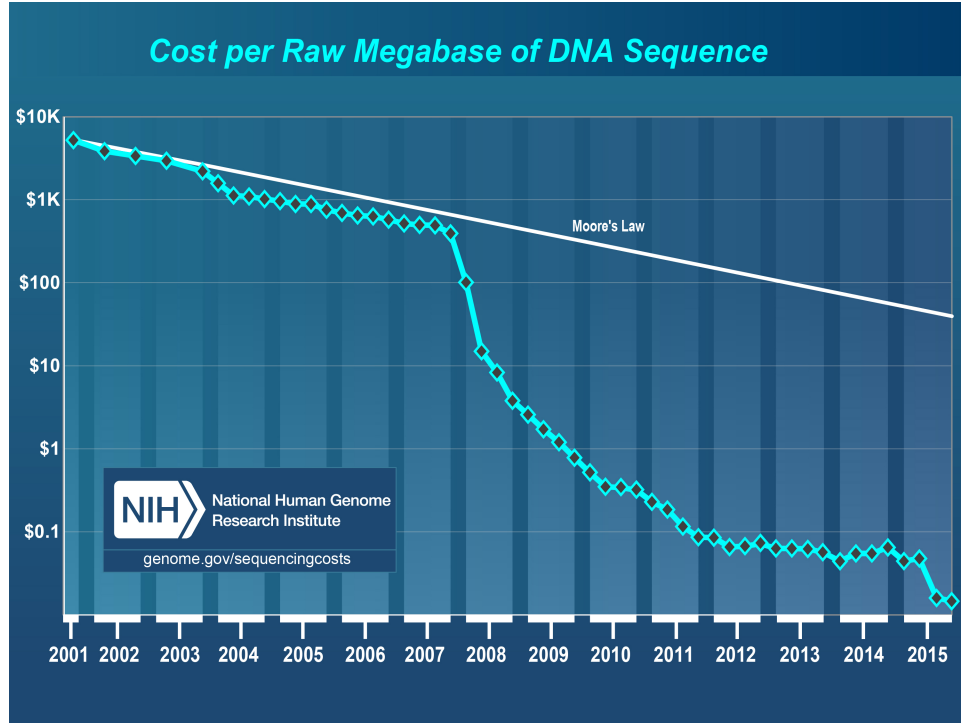


Figure 5.1 Cost per raw megabase of DNA sequence from 2001 to 2015. Straight line - Moore's Law, blue curve - cost in US dollars, Y-axis scale is logarithmic. Graph reproduced from [5]

5.2 Example of a table

Example of a table and here is the reference to Table 5.1. Tables in, my opinion, are the hardest thing to make.

Fusce ultricies pulvinar diam sed ultrices. Sed orci justo, rutrum in dolor a, consequat dictum mi. Sed luctus congue ex nec dignissim. Phasellus volutpat urna vestibulum ipsum vestibulum, quis venenatis justo consectetur. Nullam hendrerit nisl in rutrum convallis. Sed sit amet malesuada nisi. Phasellus dolor neque, vehicula vestibulum semper at, facilisis eget libero. Mauris interdum magna molestie, auctor felis a, condimentum odio. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Suspendisse maximus lacinia dignissim. Maecenas pharetra accumsan metus, sagittis dictum purus sollicitudin eget. Curabitur ut porttitor arcu, ut porttitor ipsum. Vestibulum porttitor finibus

ORGANISM	ACCESSION NO.	GENOME SIZE (bp)	No. CDS
<i>Mesorhizobium loti</i>	NC_002678	7036071	6743
<i>Sinorhizobium meliloti</i>	NC_003047	3654135	3359
<i>Bradyrhizobium japonicum</i>	NC_004463	9105828	8317
<i>Rhodopseudomonas palustris</i>	NC_005296	5459213	4813
<i>Bartonella quintana</i>	NC_005955	1581384	1142
<i>Bartonella henselae</i>	NC_005956	1931047	1488
<i>Rickettsia typhi</i>	NC_006142	1111496	837
<i>Beijerinckia indica</i>	NC_010581	4170153	3569

Table 5.1 Whole-genome sequences used in this study

sapien, ac pharetra odio bibendum nec. Nullam tincidunt dignissim risus imperdiet dictum.

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Suspendisse maximus lacinia dignissim. Maecenas pharetra accumsan metus, sagittis dictum purus sollicitudin eget. Curabitur ut porttitor arcu, ut porttitor ipsum. Vestibulum porttitor finibus sapien, ac pharetra odio bibendum nec. Nullam tincidunt dignissim risus imperdiet dictum.

5.3 Chapter section

Fusce ultricies pulvinar diam sed ultrices. Sed orci justo, rutrum in dolor a, consequat dictum mi. Sed luctus congue ex nec dignissim. Phasellus volutpat urna vestibulum ipsum vestibulum, quis venenatis justo consectetur. Nullam hendrerit nisl in rutrum convallis. Sed sit amet malesuada nisi. Phasellus dolor neque, vehicula vestibulum semper at, facilisis eget libero. Mauris interdum magna molestie, auctor felis a, condimentum odio. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Suspendisse

maximus lacinia dignissim. Maecenas pharetra accumsan metus, sagittis dictum purus sollicitudin eget. Curabitur ut porttitor arcu, ut porttitor ipsum. Vestibulum porttitor finibus sapien, ac pharetra odio bibendum nec. Nullam tincidunt dignissim risus imperdiet dictum.

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Suspendisse maximus lacinia dignissim. Maecenas pharetra accumsan metus, sagittis dictum purus sollicitudin eget. Curabitur ut porttitor arcu, ut porttitor ipsum. Vestibulum porttitor finibus sapien, ac pharetra odio bibendum nec. Nullam tincidunt dignissim risus imperdiet dictum.

REFERENCES

1. Prades, J. D., Cirera, A. & Morante, J. R. Ab initio calculations of NO₂ and SO₂ chemisorption onto non-polar ZnO surfaces. *Sensors and Actuators, B: Chemical* **142**, 179–184 (1 Oct. 2009).
2. Erhart, P. & Albe, K. Diffusion of zinc vacancies and interstitials in zinc oxide. *Applied Physics Letters* **88** (20 May 2006).
3. Altschul, S. F. *et al.* Gapped BLAST and PSI-BLAST: a new generation of protein database search programs. *Nucleic acids research* **25**, 3389–3402 (1997).
4. Baker, S. *et al.* A novel linear plasmid mediates flagellar variation in Salmonella Typhi. *PLoS Pathog* **3**, e59 (2007).
5. Wetterstrand, K. A. *DNA Sequencing Costs: Data from the NHGRI Genome Sequencing Program (GSP)* www.genome.gov/sequencingcosts.

APPENDIX

Appendix A

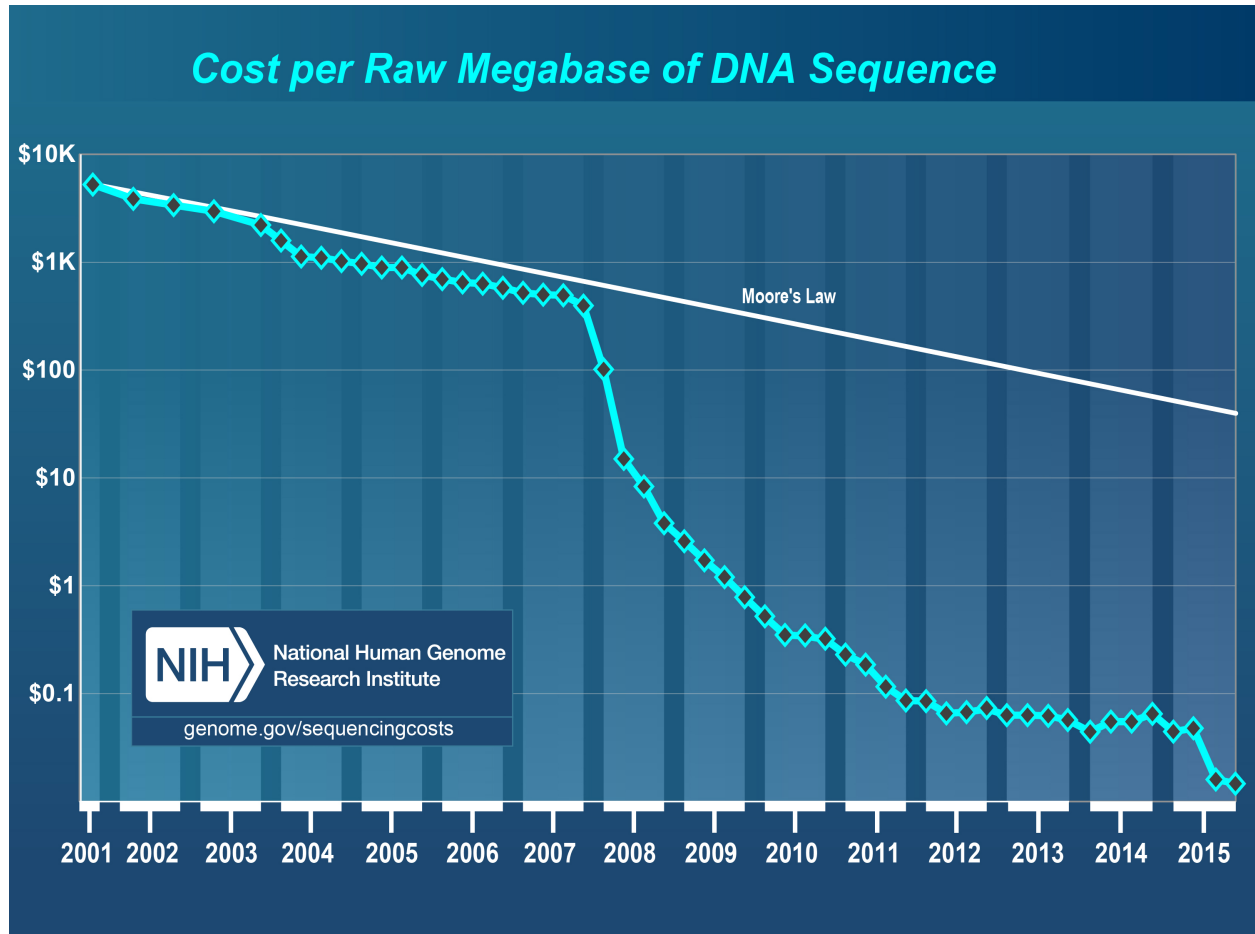


Figure A.1 Cost per raw megabase of DNA sequence from 2001 to 2015. Straight line - Moore's Law, blue curve - cost in US dollars, Y-axis scale is logarithmic. Graph reproduced from [5]

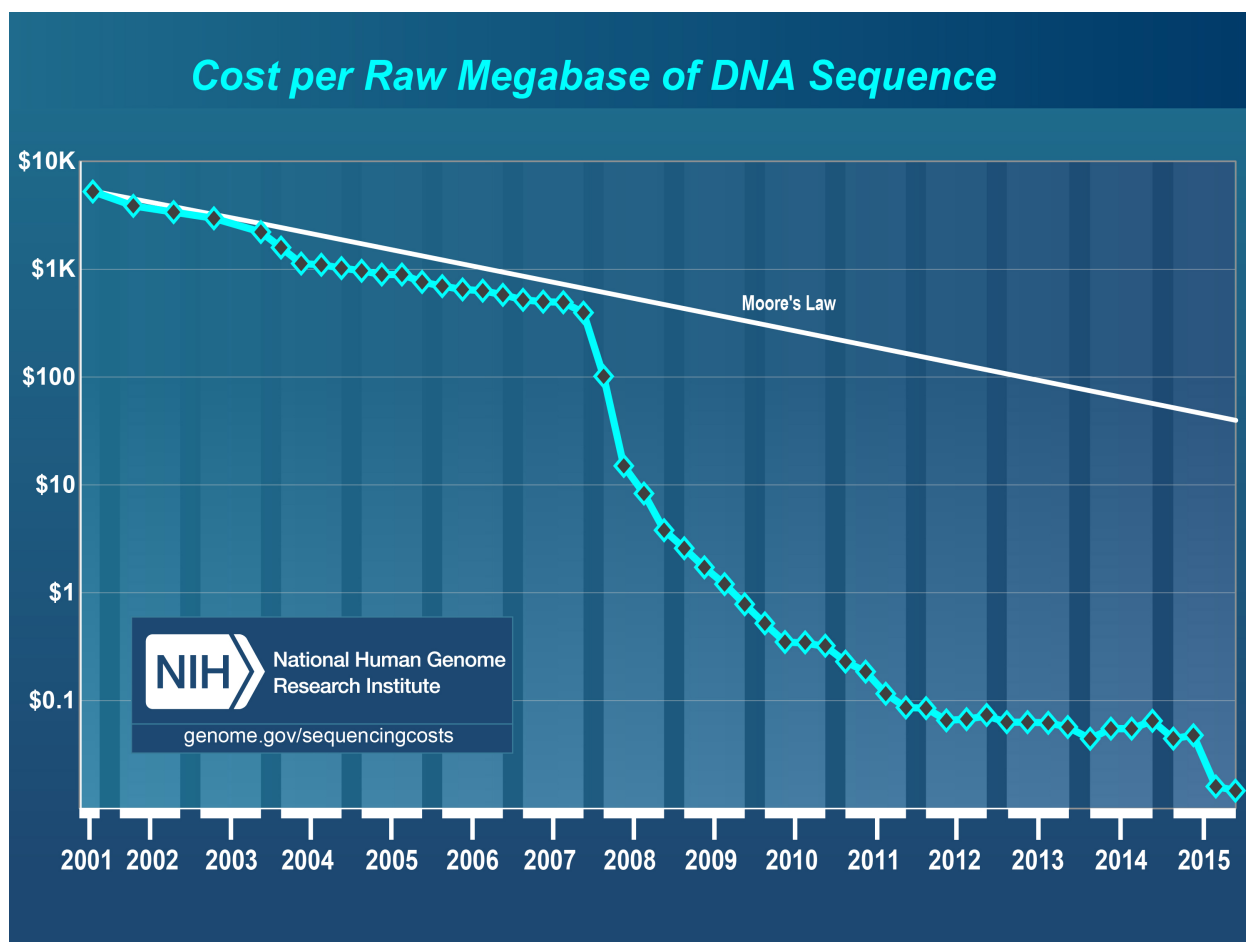


Figure A.2 Cost per raw megabase of DNA sequence from 2001 to 2015. Straight line - Moore's Law, blue curve - cost in US dollars, Y-axis scale is logarithmic. Graph reproduced from [5]

Appendix B

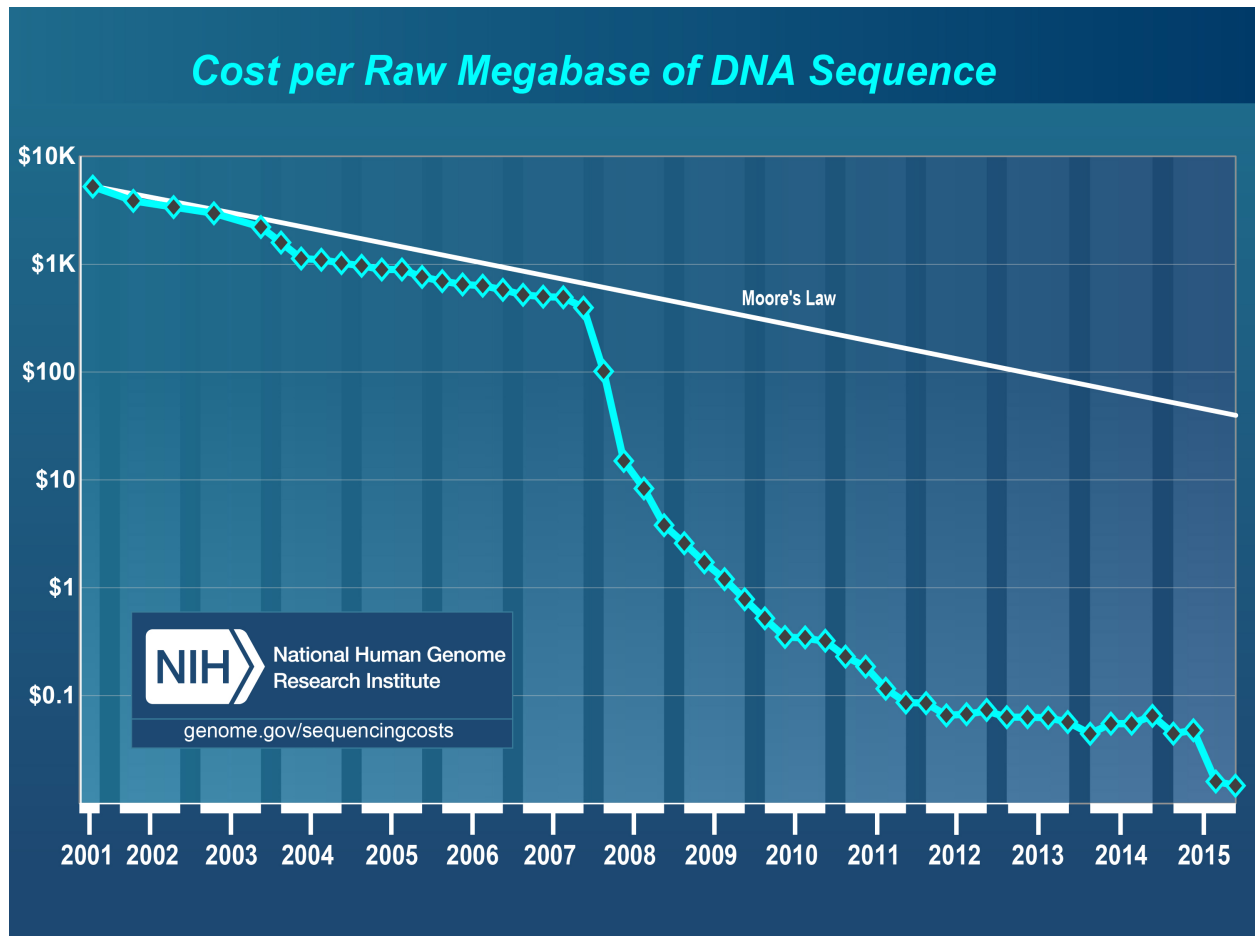


Figure B.1 Cost per raw megabase of DNA sequence from 2001 to 2015. Straight line - Moore's Law, blue curve - cost in US dollars, Y-axis scale is logarithmic. Graph reproduced from [5]

Appendix C

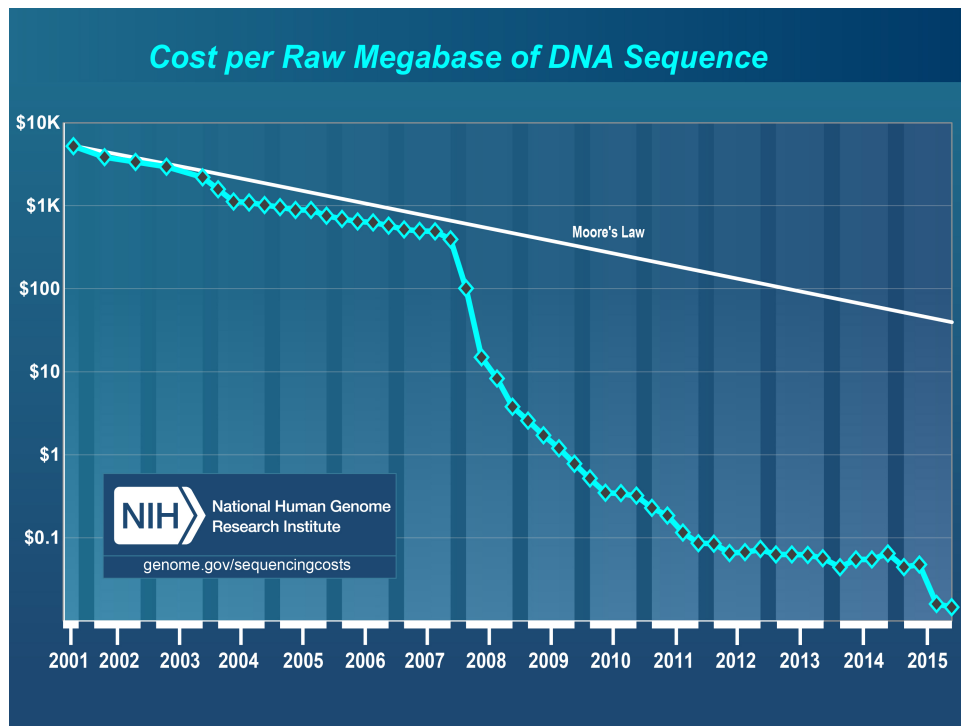


Figure C.1 Cost per raw megabase of DNA sequence from 2001 to 2015. Straight line - Moore's Law, blue curve - cost in US dollars, Y-axis scale is logarithmic. Graph reproduced from [5]

Appendix D

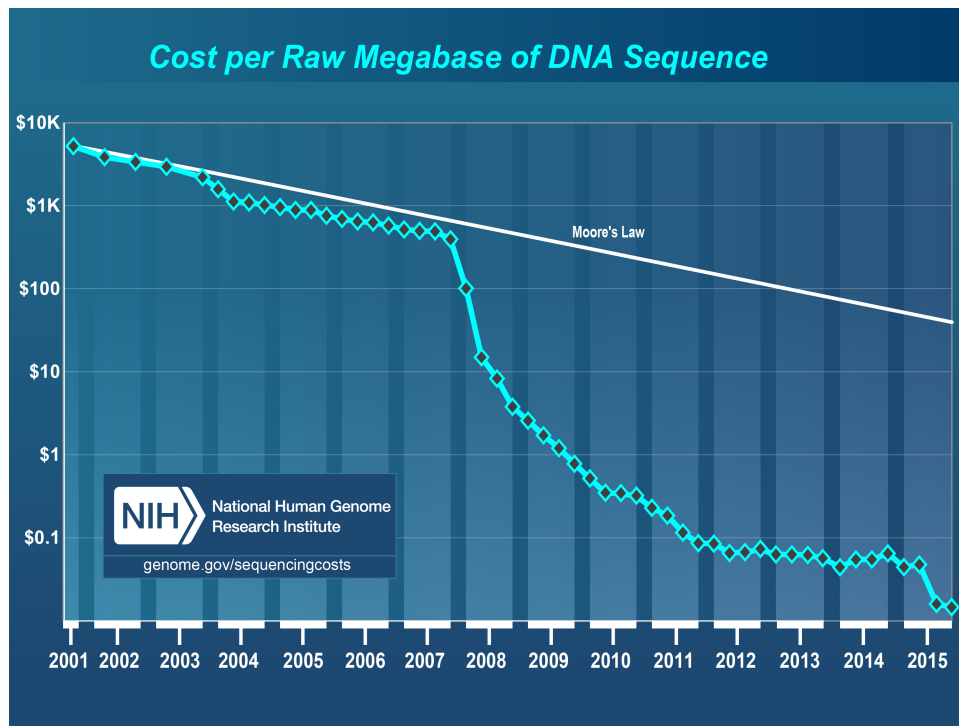


Figure D.1 Cost per raw megabase of DNA sequence from 2001 to 2015. Straight line - Moore's Law, blue curve - cost in US dollars, Y-axis scale is logarithmic. Graph reproduced from [5]

Appendix E

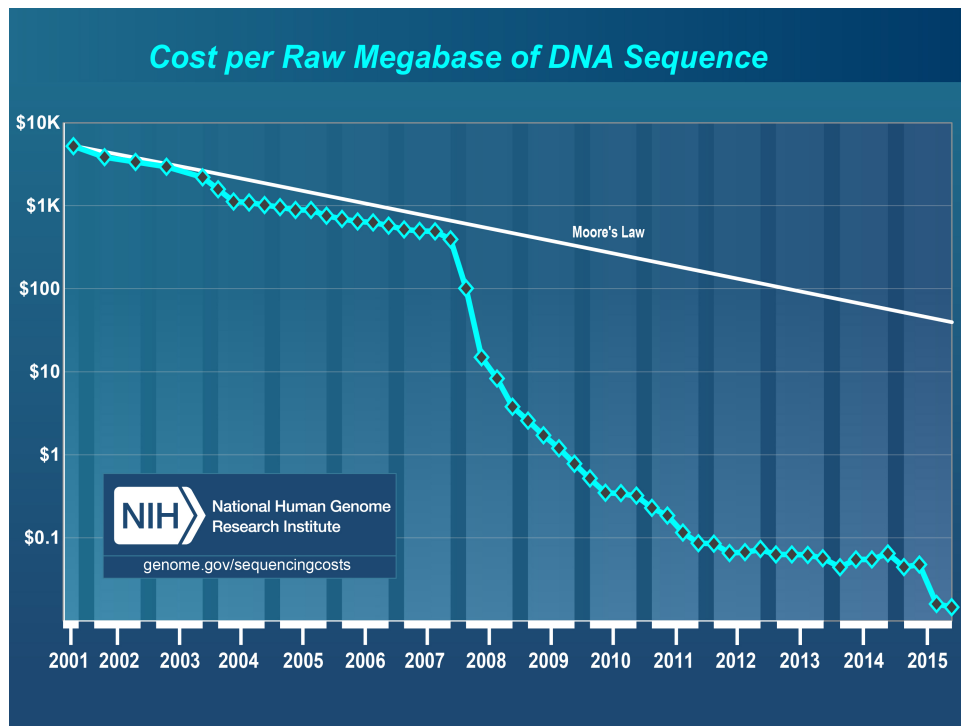


Figure E.1 Cost per raw megabase of DNA sequence from 2001 to 2015. Straight line - Moore's Law, blue curve - cost in US dollars, Y-axis scale is logarithmic. Graph reproduced from [5]