Programming for Data Analysis: Introduction

Kasthuri Kannan, PhD
Associate Professor
Translational Molecular Pathology
UT MD Anderson Cancer Center

Envisioned to empower

Not about R

Using R all the time

Not about programming

Program all the time

Not about big data, Hadoop, distributed comp. etc.

Do data science all the time

Not about machine learning, stat. inference etc.

Course on machine learning offered in Spring

Contents

Data science, a hype?

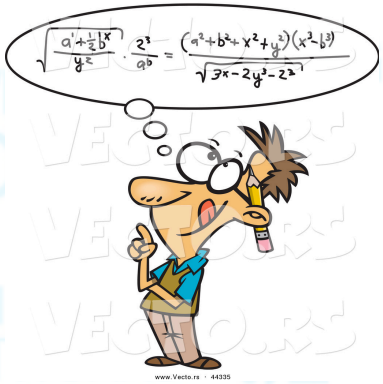
Why am I here?

Why data science?

Hopefully, there is no penalty drop-out date

Ok, so tell me what is data science?

I'll stay put if you don't kill us with equations



What is this course about?

DATA SCIENCE, A HYPE?

Data science in media

The New York Times

BIG DATA

Less Noise but More Money in Data Science

BY STEVE LOHR APRIL 28, 2015 9:30 AM 10

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The outlook for data scientists: less hype, more hiring.

The exuberance surrounding big data has passed its peak and is trending down, the technology research firm Gartner declared last August in its annual "hype cycle" report on perceptions of technology.

Perhaps, but it remains a rising market for data scientists. Salaries rose 8 percent on average in the last year, with bonuses adding $56,000, according to a salary and employment survey released on Tuesday by Burtch Works, a recruiter of professionals with quantitative skills.

Harvard Business Review

DATA

Data Scientist: The Sexiest Job of the 21st Century

by Thomas H. Davenport and D.J. Patil

FROM THE OCTOBER 2012 ISSUE

WHAT TO READ NEXT

Big Data: The Management Revolution

Bloomberg Markets Tech Pursuits Politics Opinion Businessweek

Here's a Retail Job That's Still in High Demand: Data Scientist

By Taylor Cromwell

August 21, 2017, 7:00 AM EDT

CIO FROM IDG

FEATURE

What is a data scientist? A key data analytics role and a lucrative career

Becoming a data scientist varies depending on industry, but there are common skills, experience, education and training that will give you the leg up in starting your data science career.

By Sarah K. White

Senior Writer, CIO | AUG 18, 2017 3:00 AM PT

RTInsights.com

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Home / Analytics / Why You May Want a Career in Data Science

Why You May Want a Career in Data Science

By Dan Muse | August 17, 2017

Data science in academia

NSF Announces $17.7 Million Funding for Data Science Projects

August 25, 2017 by staff Leave a Comment

NYU

DATA SCIENCE AT NYU

About What is data science? Research Academics News Contact Us

Research

RESEARCH CENTERS IN THE FIELD OF DATA SCIENCE

Center for Data Science (CDS)

The NYU Center for Data Science (CDS) is a focal point for New York University's university-wide initiative in data science. It was established to help advance NYU's goal of creating the country's leading data science training and research facilities, arming researchers and professionals with tools to harness the power of big data.

500k

The world's 500,000+ data centres are large enough to fill 5,955 football fields. *(Source: Kurtosys)*

BETHEL UNIVERSITY

Undergrad Adult Undergrad Graduate Seminary Online

New Major Addresses Fast-Growing Field of Data Science

News › August

August 29, 2017 | 11 a.m.

Big data will be focus of new UW research institute

By Erik Lorenzsonn Sep 2, 2017

KSU launches Analytics and Data Science Institute

Staff reports Aug 25, 2017 Comments

NSF awards $1.5 million grant for data science research at UC Santa Cruz

A cross-disciplinary team of computer scientists, statisticians, and mathematicians is developing the theoretical foundations of the emerging field of data science

PUBLIC RELEASE: 24-AUG-2017

Brown awarded $1.5M to establish data science research institute

BROWN UNIVERSITY

Demand is likely to outpace supply

Demand in data science

At its core, data science involves using automated methods to analyze massive amounts of data and to extract knowledge from them. With such automated methods turning up everywhere from genomics to high-energy physics, data science is helping to create new branches of science, and influencing areas of social science and the humanities.

50X in 2020

The world will generate 50 times more data than was generated in 2011.

The U.S. alone is going to face a **shortage of 140,000 to 200,000** professionals with data science skills by **2018.**

Source: Mckinsey Global Institute

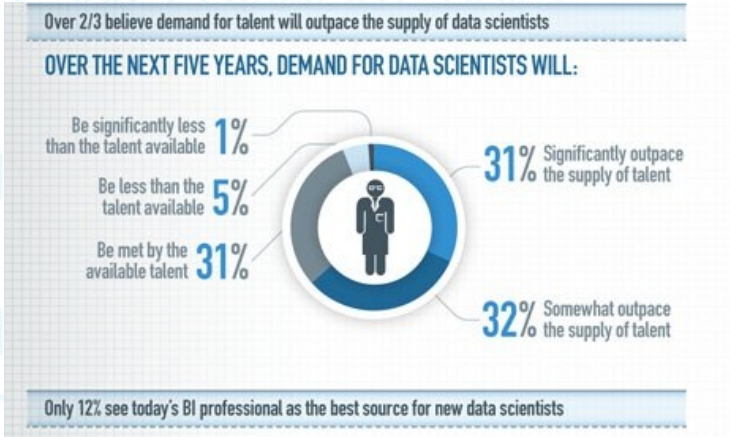
No. **1** The position of "data scientist" on the list of the 25 best jobs in America in 2016.

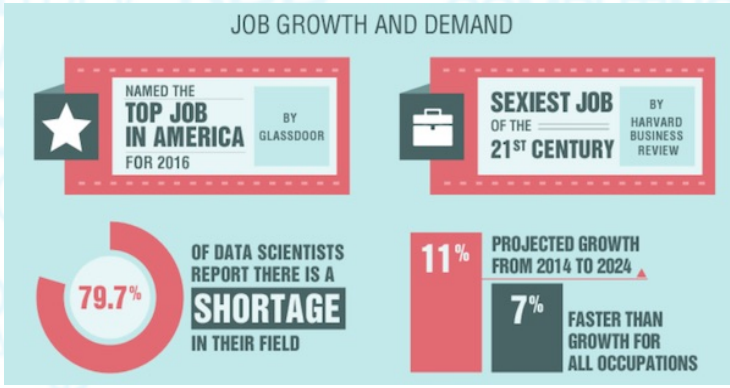
$116,840

median salary in the US.

94%

of the US graduates have found jobs, averaging **$114,000** since 2011.





Extremely well-paid career

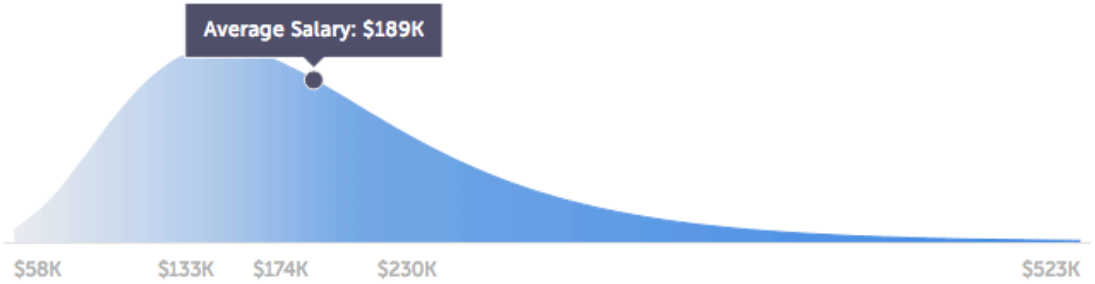
The average salary for Data Scientists is $189K.★

Sign in to see how much you should be making »

← $189K →

AVERAGE MARKET SALARY

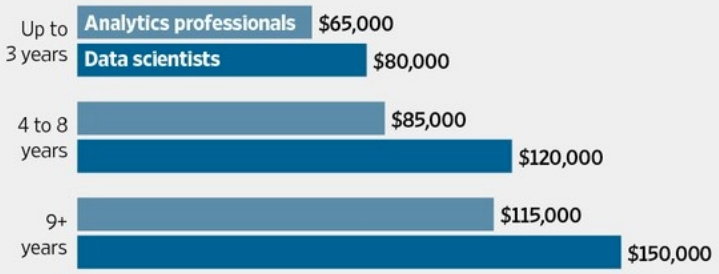
BASE SALARY	$107K
ANNUAL BONUS	$26K
ANNUAL EQUITY	$56K
ONE-TIME SIGNING BONUS	$20K



How competitive are Data Scientist salaries?
The average market salary for employees is $189K per year, ranging from $110K to $276K.

Big Data, Big Paycheck

Median salary for analytics professionals and those specifically within data science, by level of experience.



Note: Data do not include managers Source: Burtch Works The Wall Street Journal

Data Scientist salaries in San Francisco, CA

$140,703 per year

Based on 4,567 salaries

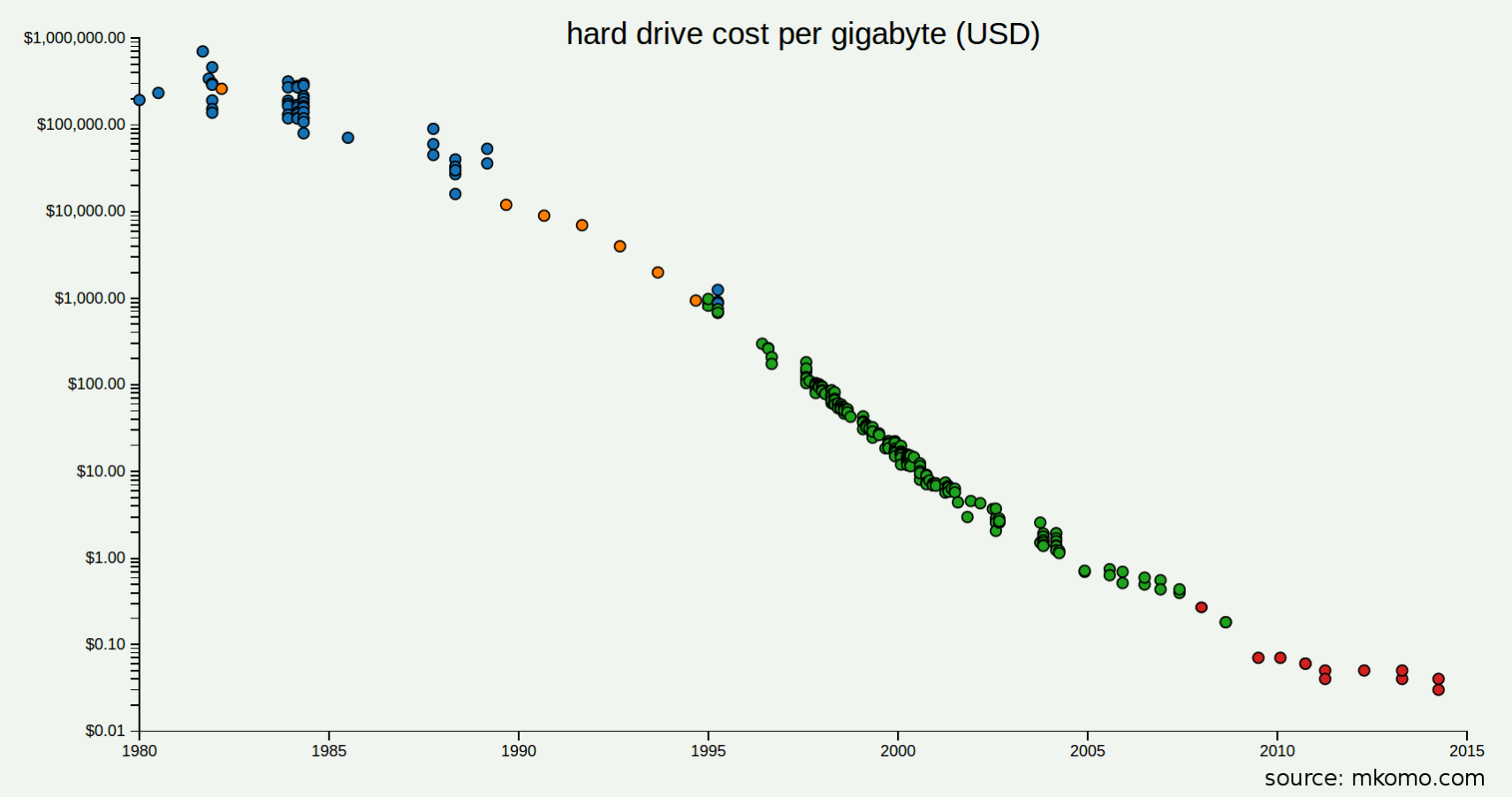
Data Scientist salaries by company in San Francisco, CA

★PAYSA.com

WHY DATA SCIENCE?

Drastic reduction in storage costs

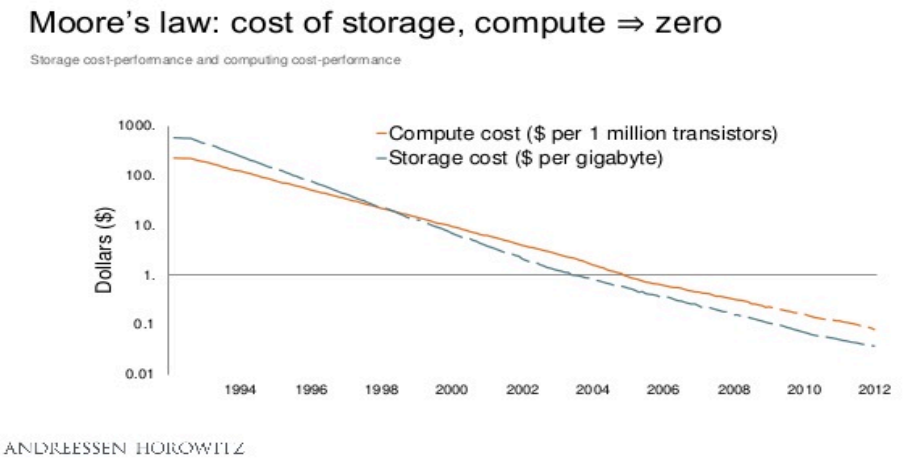
Technology = Reduction in storage cost

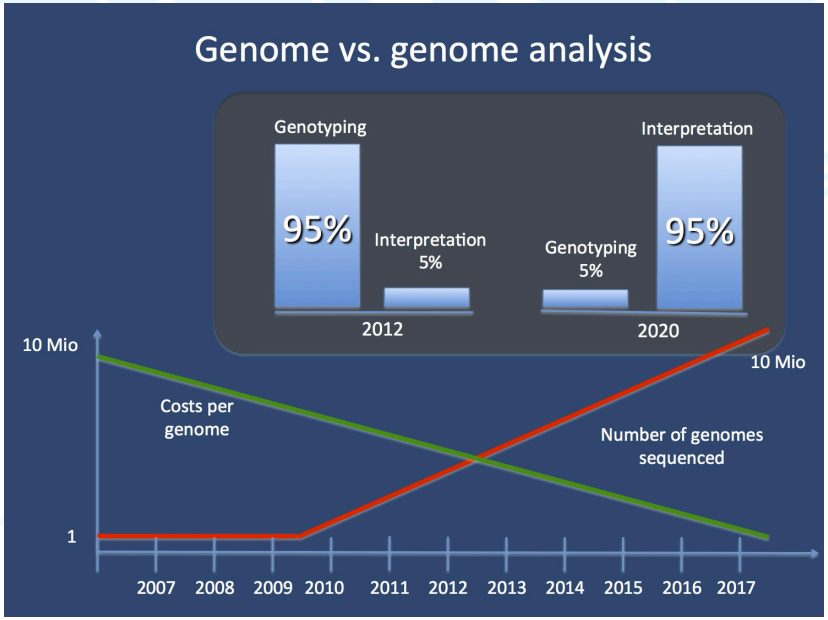


Drastic reduction in computation costs

Technology = Reduction in computing cost

Moore's law refers to an observation made by Intel co-founder Gordon Moore in 1965. He noticed that the number of transistors per square inch on integrated circuits had doubled every year since their invention. Moore's law predicted that this trend will tend to continue into the foreseeable future. It is almost ending now, though.





Big data has immense value

Capitalizing on Big Data:

Strategies outperforming companies are taking to deliver results

Leaders are **166%** more likely to **make most decisions based** on data

And they are **2.2x** more likely to have **formal career path** for analytics

75% of Leaders cite **growth as the key source of value** from analytics

Leaders **measure the impact** of analytics investments

Leaders have **predictive analytics** capabilities

Leaders have some form of **shared analytics resources**

Join the conversation on Twitter at #ibmanalytics and follow @IBMIBV

Source: *Analytics: A blueprint for value - Converting big data and analytics insights into results*
IBM Institute for Business Value.

ibm.co/9levers

IBM

Raising expectations

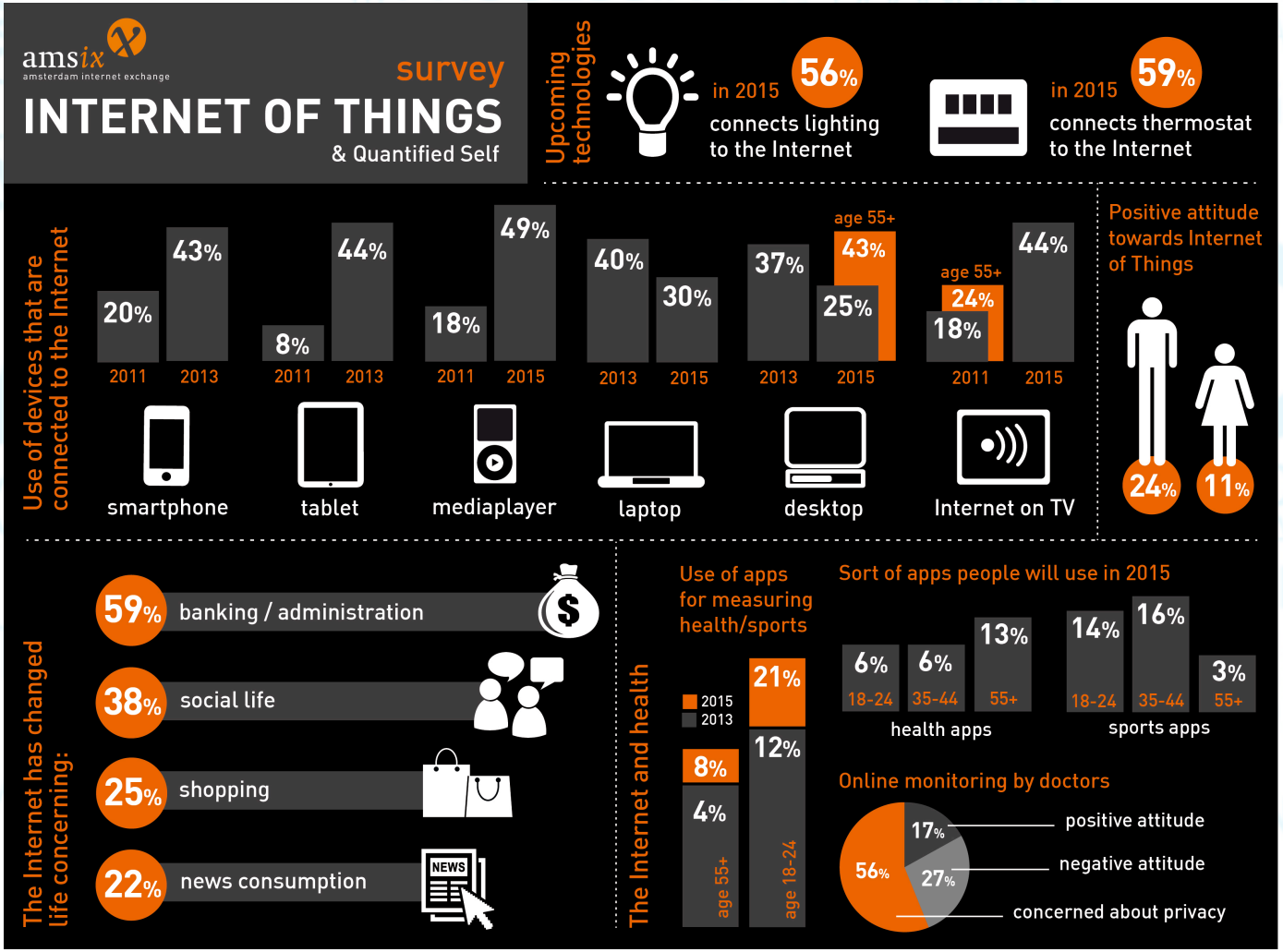
Cognitive computing

People expect systems to behave like humans

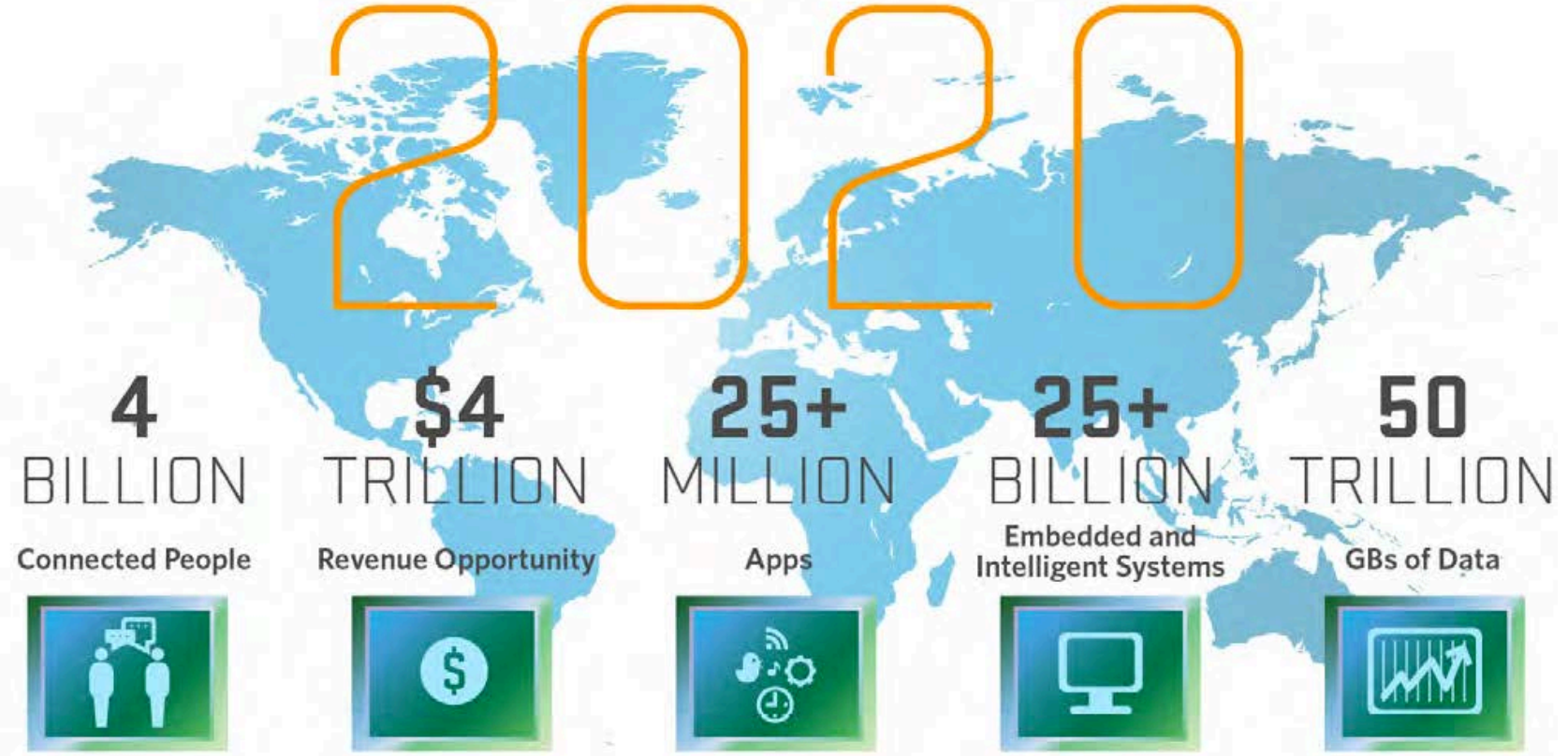
- **Adaptive (learning as the information changes)**
- **Interactive (communicating with other humans/systems)**
- **Contextual (understanding meanings, integrate other info)**

Processing large datasets of differing types like text, voice, sensors and images.

Internet of Things: The next frontier

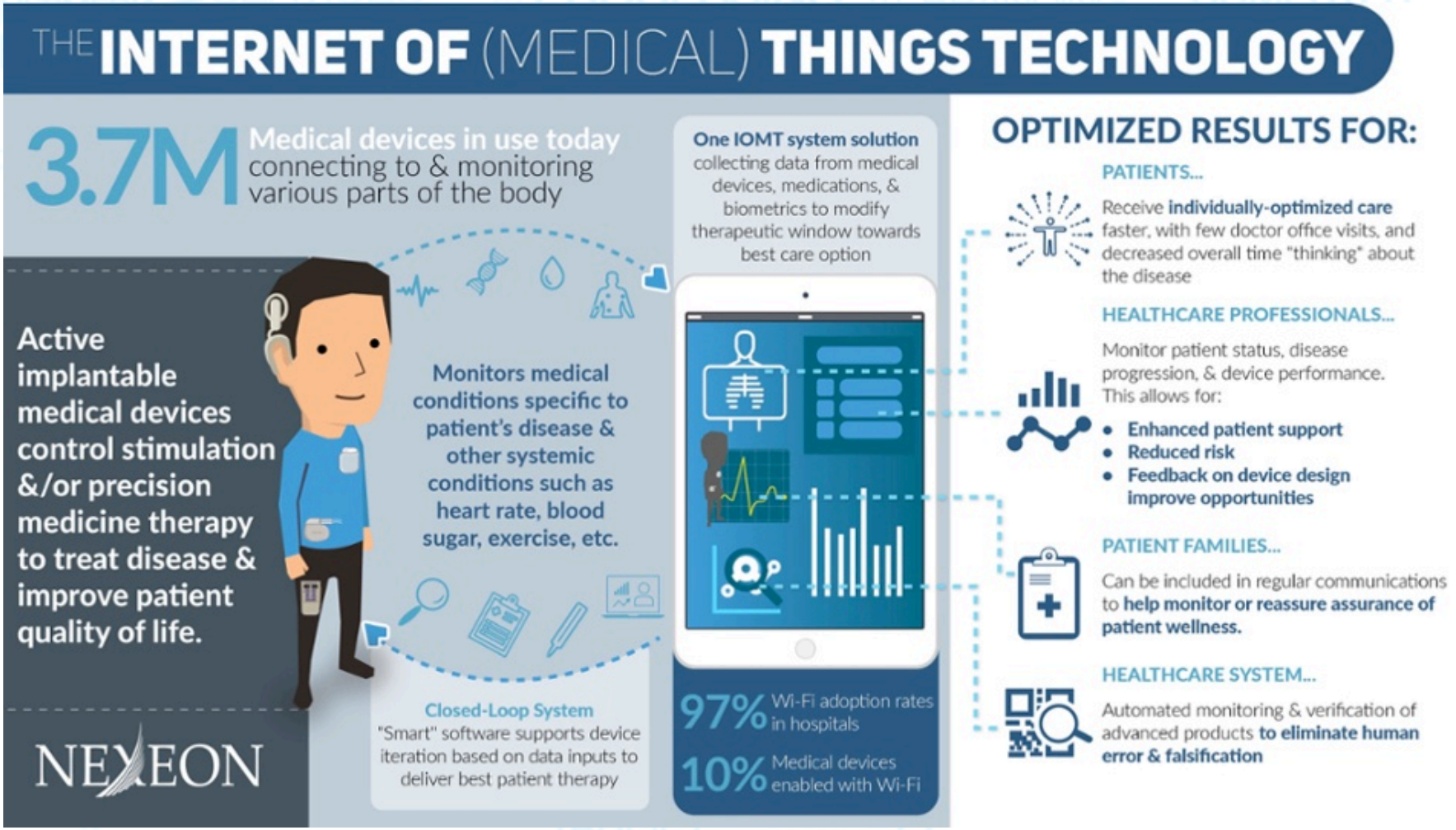


Internet of Things: Projection

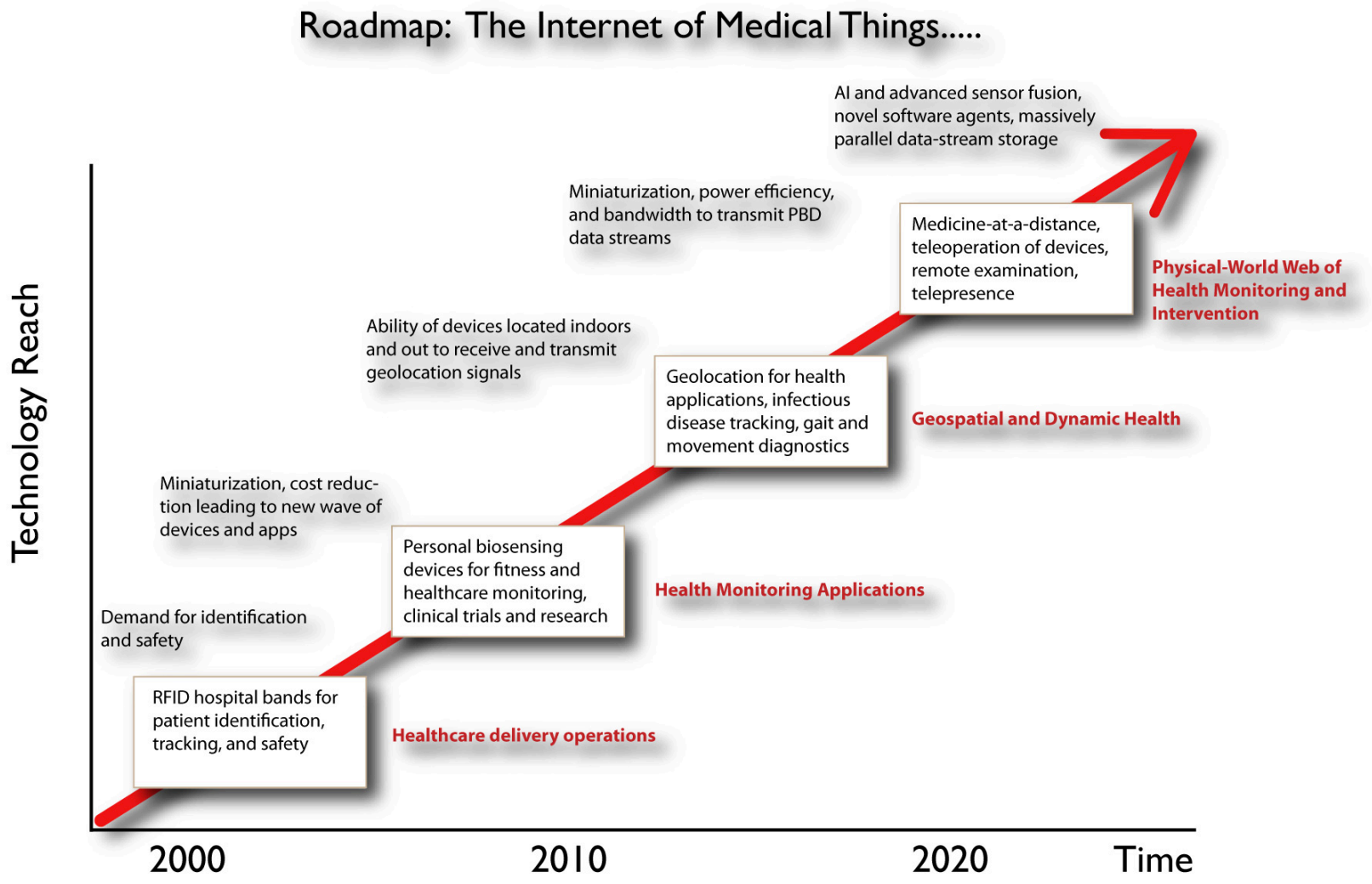


Source: Mario Morales, IDC

Why biomedical data science?



Io(M)T: Tech vs. Time



BIGDATAMEDSCI.COM

WHAT IS DATA SCIENCE?

A mash up of disciplines

An umbrella term for techniques used when trying to extract insights and information from the data.

Math and Theory	• Statistics, Linear Algebra, Optimization, Time Series, etc.
Applied Algorithms	• Machine Learning, Data Structures, Parallel Algorithms, etc.
Engineering and Technologies	• Storage and computing platforms, statistical tools ,etc.
Domain Expertise	• Text, Finance, Images, Econometrics etc.
Art	• Visualization, Infographics
Best practices and hacks	• Handle missed values in data, transform and represent data, etc.

Example: Data science in healthcare

Survival analysis

Analyze survival statistics for different patient attributes (like age, gender, blood type) and treatments.

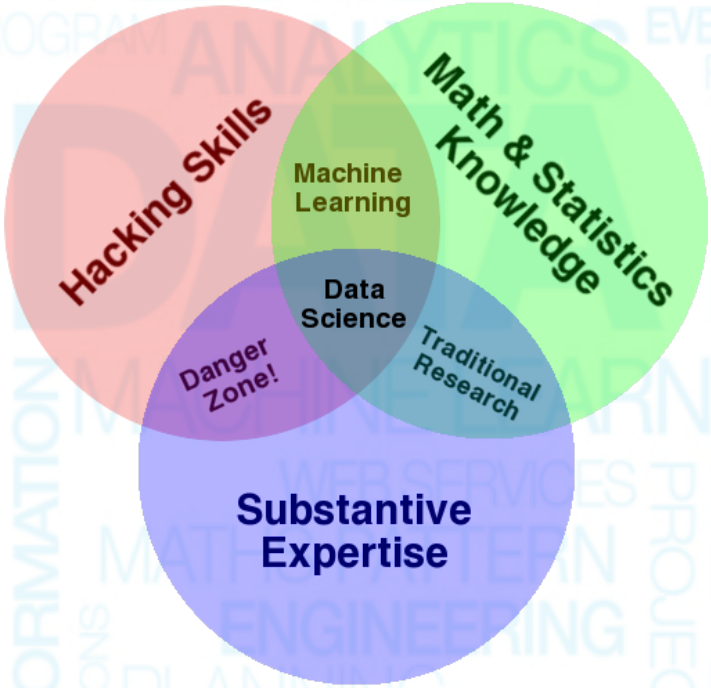
Dosage effectiveness

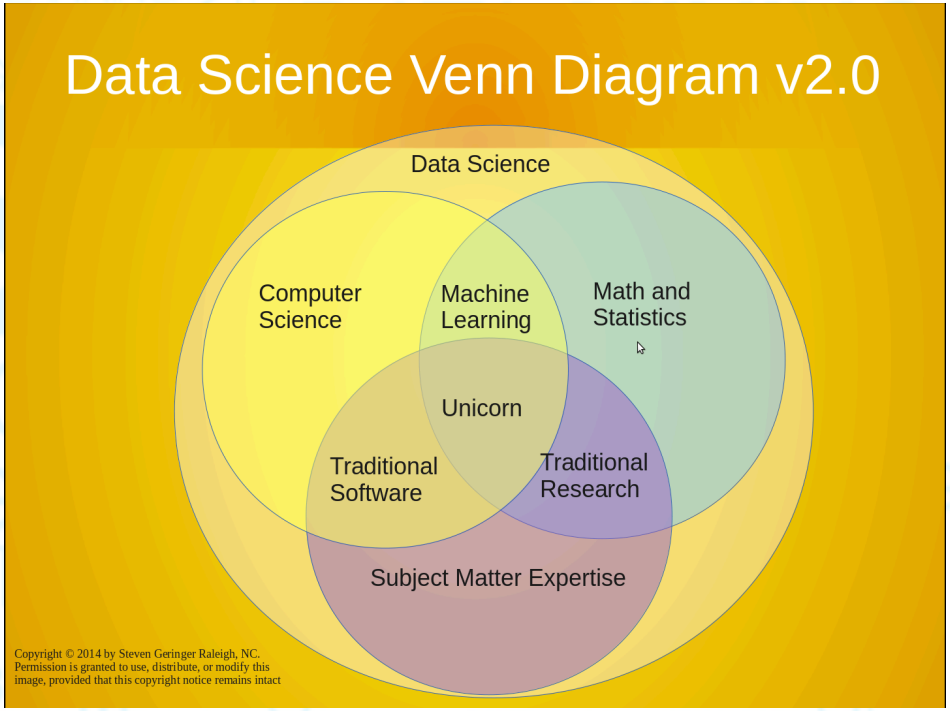
Study the effectiveness of the dosage from the measured variables based on the medication for a disease.

Readmission risk

Predict the risk of readmission based on patient attributes, medical history, diagnosis and treatment.

A note on Venn diagrams

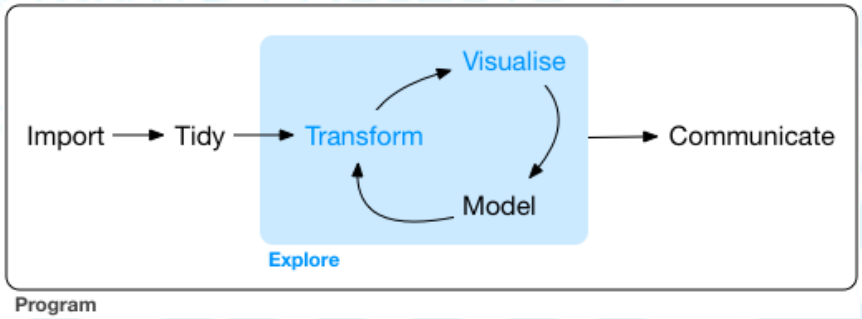


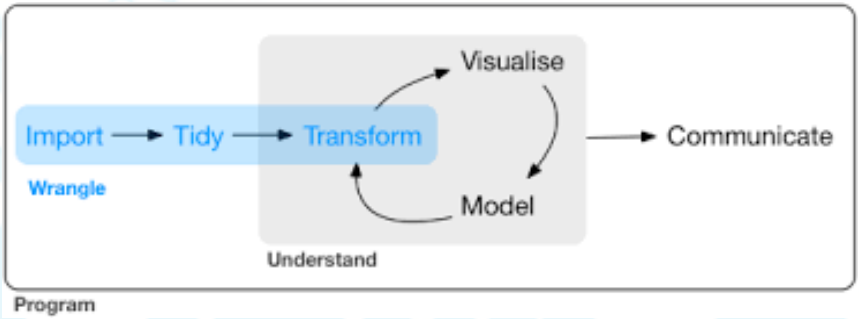


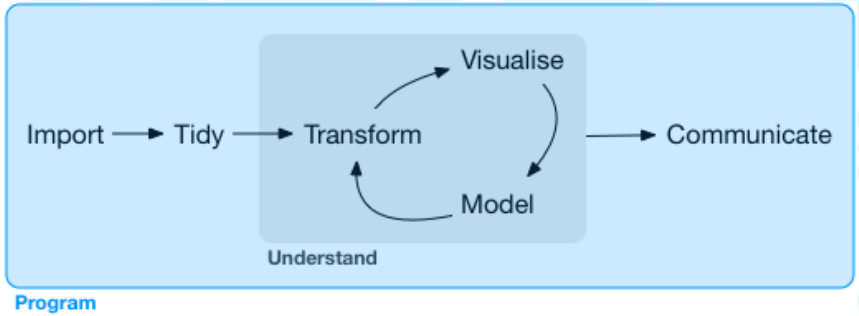
Drew Conway's definition

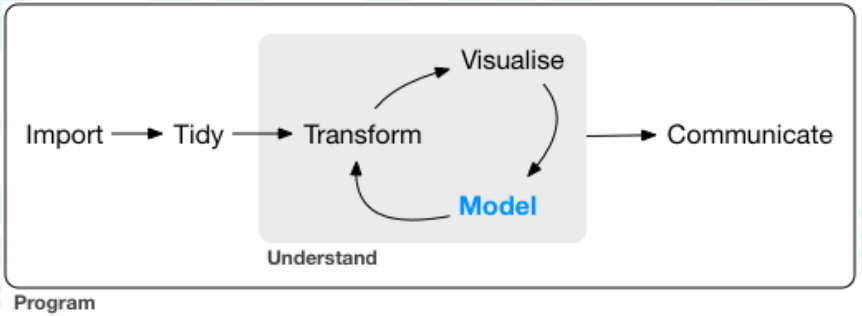
Steven Geringer's definition

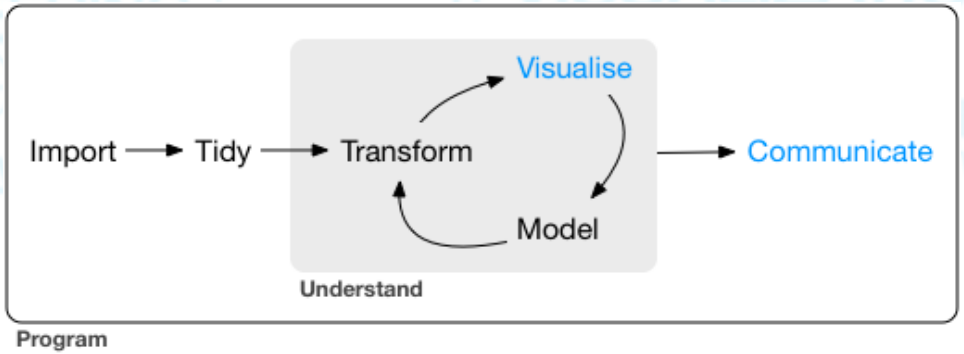
Doing data science: Explore, Wrangle, Program, Model and Communicate











Data scientist: Amalgamation of skills

MODERN DATA SCIENTIST

Data Scientist, the sexiest job of the 21th century, requires a mixture of multidisciplinary skills ranging from an intersection of mathematics, statistics, computer science, communication and business. Finding a data scientist is hard. Finding people who understand who a data scientist is, is equally hard. So here is a little cheat sheet on who the modern data scientist really is.

MATH & STATISTICS

- Machine learning
- Statistical modeling
- Experiment design
- Bayesian inference
- Supervised learning: decision trees, random forests, logistic regression
- Unsupervised learning: clustering, dimensionality reduction
- Optimization: gradient descent and variants

PROGRAMMING & DATABASE

- Computer science fundamentals
- Scripting language e.g. Python
- Statistical computing packages, e.g., R
- Databases: SQL and NoSQL
- Relational algebra
- Parallel databases and parallel query processing
- MapReduce concepts
- Hadoop and Hive/Pig
- Custom reducers
- Experience with xaaS like AWS

DOMAIN KNOWLEDGE & SOFT SKILLS

- Passionate about the business
- Curious about data
- Influence without authority
- Hacker mindset
- Problem solver
- Strategic, proactive, creative, innovative and collaborative

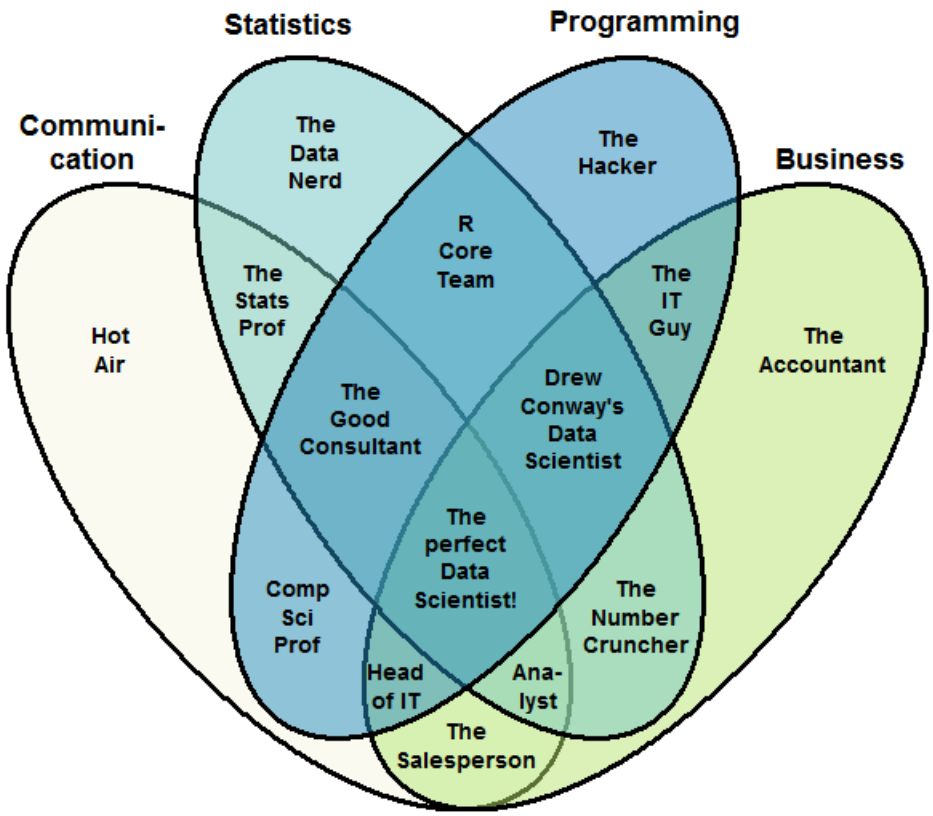
COMMUNICATION & VISUALIZATION

- Able to engage with senior management
- Story telling skills
- Translate data-driven insights into decisions and actions
- Visual art design
- R packages like ggplot or lattice
- Knowledge of any of visualization tools e.g. Flare, D3.js, Tableau

MarketingDistillery.com is a group of practitioners in the area of e-commerce marketing. Our fields of expertise include: marketing strategy and optimization: customer tracking and on-site analytics: predictive analytics and econometrics: data warehousing and big data systems: marketing channel insights in Paid Search, SEO, Social, CRM and brand.

Marketing DISTILLERY
(c) Krzysztof Zawadzki

The Data Scientist Venn Diagram ★



★ https://datascience.stackexchange.com/questions/2403/data-science-without-knowledge-of-a-specific-topic-is-it-worth-pursuing-as-a-ca

Data analysts vs. Data scientists

	ANALYSTS	DATA SCIENTISTS
Types of data	Structured and semistructured, mostly numeric data	All types, including unstructured, numeric and nonnumeric data (such as images, sound, text)
Preferred tools	Statistical and modeling tools, usually contained in a data repository	Mathematical languages (such as R and Python), machine learning, natural language processing and open-source tools that access and manipulate data on multiple servers (such as Hadoop)
Nature of work	Report, predict, prescribe and optimize	Explore, discover, investigate and visualize
Typical educational background	Operations research, statistics, applied mathematics, predictive analytics	Computer science, data science, symbolic systems, cognitive science
Mind-set	Percentage who say they: •are entrepreneurial: 69% •explore new ideas: 58% •gain insights outside of formal projects: 54%	Percentage who say they: •are entrepreneurial: 96% •explore new ideas: 85% •gain insights outside of formal projects: 89%

Roles and paychecks

DATA ENGINEER
"SOFTWARE ENGINEERS BY TRADE"

Role
Develops, constructs, tests and maintains architectures (such as databases and large-scale processing systems)

Mindset
All-purpose everyman

HIRED BY

Languages
SQL, Hive, Pig, R, Matlab, SAS, SPSS, Python, Java, Ruby, C++, Perl

Skills & Talents
- ✓ *Database systems (SQL & NO SQL based)*
- ✓ *Data modeling & ETL tools*
- ✓ *Data APIs*
- ✓ *Data warehousing solutions*

DATA SCIENTIST
"AS RARE AS UNICORNS"

Languages
R, SAS, Python, Matlab, SQL, Hive, Pig, Spark

Skills & Talents
- ✓ *Distributed computing*
- ✓ *Predictive modeling*
- ✓ *Story-telling and visualizing*
- ✓ *Math, Stats, Machine Learning*

Role
Cleans, massages and organizes (big) data

Mindset
Curious data wizard

HIRED BY

DATABASE ADMINISTRATOR
"DATABASE CARETAKER"

Role
Ensures that the database is available to all relevant users, is performing properly and is being kept safe

Mindset
Master of Disaster Prevention

HIRED BY

Languages
SQL, Java, Ruby on Rails, XML, C#, Python

Skills & Talents
- ✓ *Backup & recovery*
- ✓ *Data modeling and design*
- ✓ *Distributed Computing (Hadoop)*
- ✓ *Database systems (SQL and NO SQL based)*
- ✓ *Data security*
- ✓ *ERP & business knowledge*

BUSINESS ANALYST
"CHANGE AGENT"

Languages
SQL

Skills & Talents
- ✓ *Basic tools (e.g. MS Office)*
- ✓ *Data visualization tools (e.g. Tableau)*
- ✓ *Conscious listening and storytelling*
- ✓ *Business Intelligence understanding*
- ✓ *Data modeling*

HIRED BY

Role
Improves business processes as intermediary between business and IT

Mindset
Resilient project juggler

Salary Trend – Data Scientist Experts
www.Indeed.com (2013-2014)

ABOUT THIS COURSE

More practice than theory

A very basic course (introductory but not elementary)

- Designed with biology and medical majors in mind.
- Theory to bare minimum (only in the context of programming).

Focus on practical aspects (means programming)

- Adapting to advancement in technologies (Rstudio etc.)
- Emphasis on communication, reproducibility and version control (Rmarkdown, Git etc.)
- Working with databases

Focus on biomedical and population health data sets

Language of choice: R

AVERAGE SALARY FOR High Paying Skills and Experience

SKILL	2013	YR/YR CHANGE
R	$ 115,531	n/a
NoSQL	$ 114,796	1.6%
MapReduce	$ 114,396	n/a
PMBok	$ 112,382	1.3%
Cassandra	$ 112,382	n/a
Omnigraffle	$ 111,039	0.3%
Pig	$ 109,561	n/a
SOA (Service Oriented Architecture)	$ 108,997	-0.5%
Hadoop	$ 108,669	-5.6%
Mongo DB	$ 107,825	-0.4%

What you are encouraged to know (not essential)

Data is usually represented as a matrix

A little linear algebra will go a long way (you may want to attend my linear algebra lecture on Sept. 27)

In data science, most problems are vague

Probability, statistics & machine learning are very important

Fundamental concepts in algorithms and data structures

Big data requires non-trivial data structures and algorithms (you may want to attend my algorithms lecture on Sept. 25)

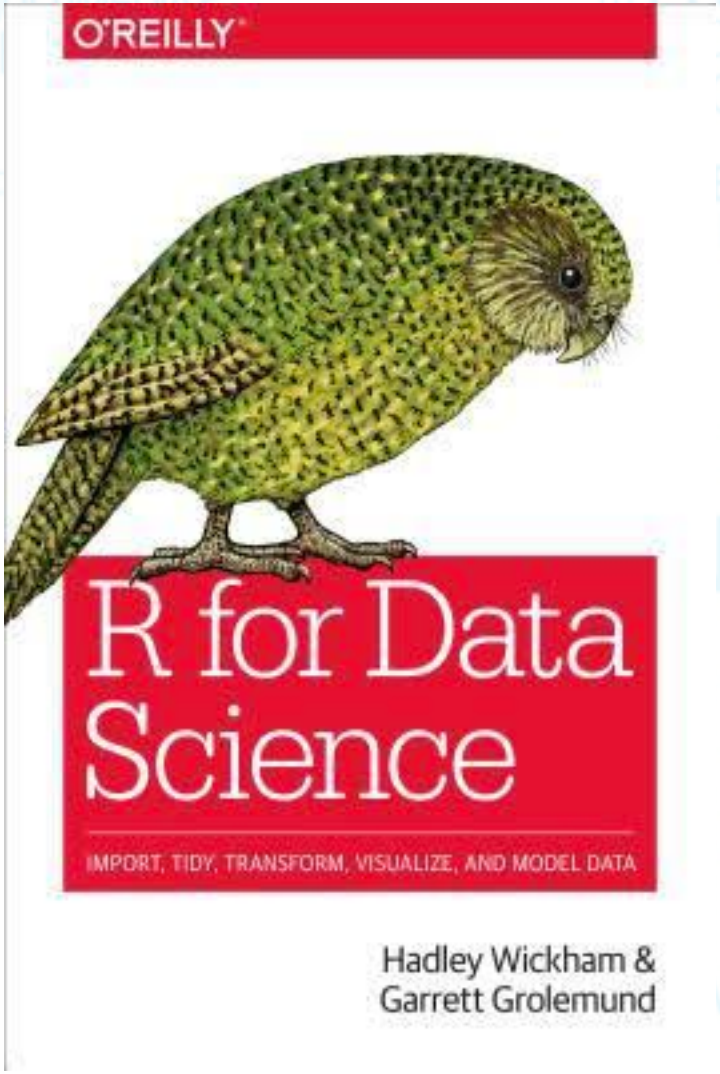
High-performance computing

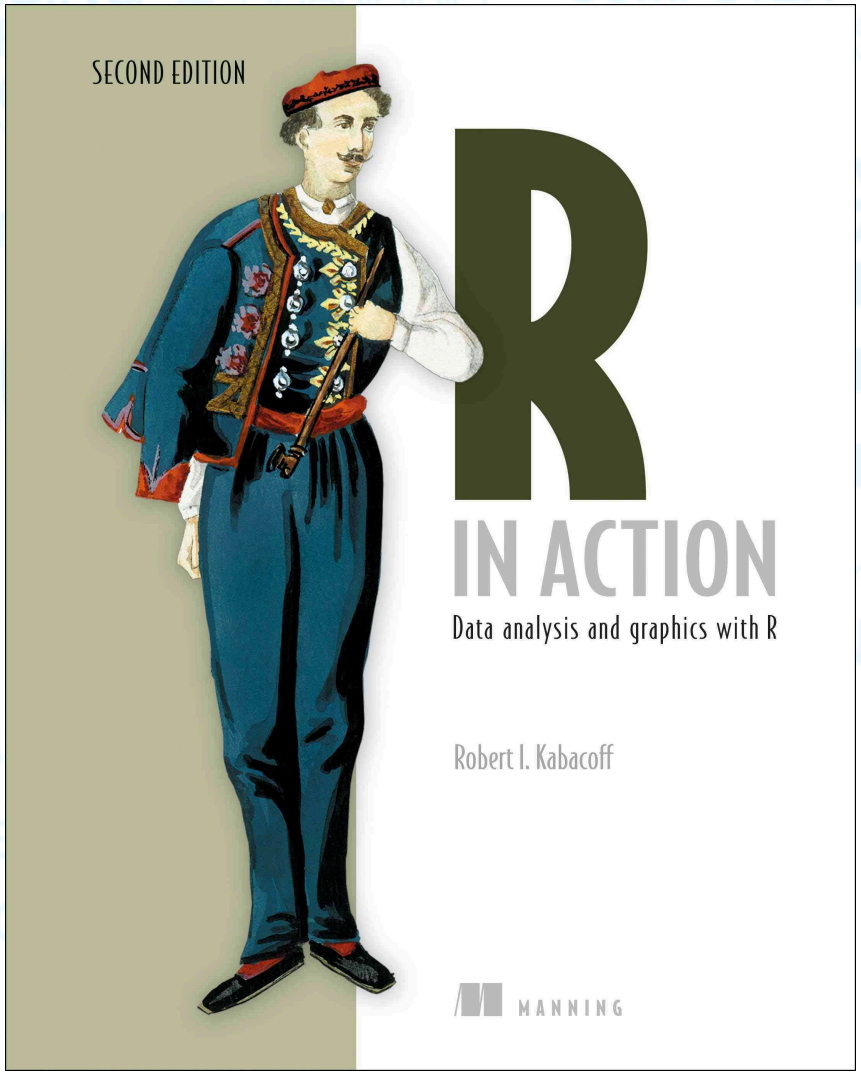
We have a very good facility here for HPC

Genomics/Epigenetics

Io(M)T will integrate genomics/epigenetics as we progress

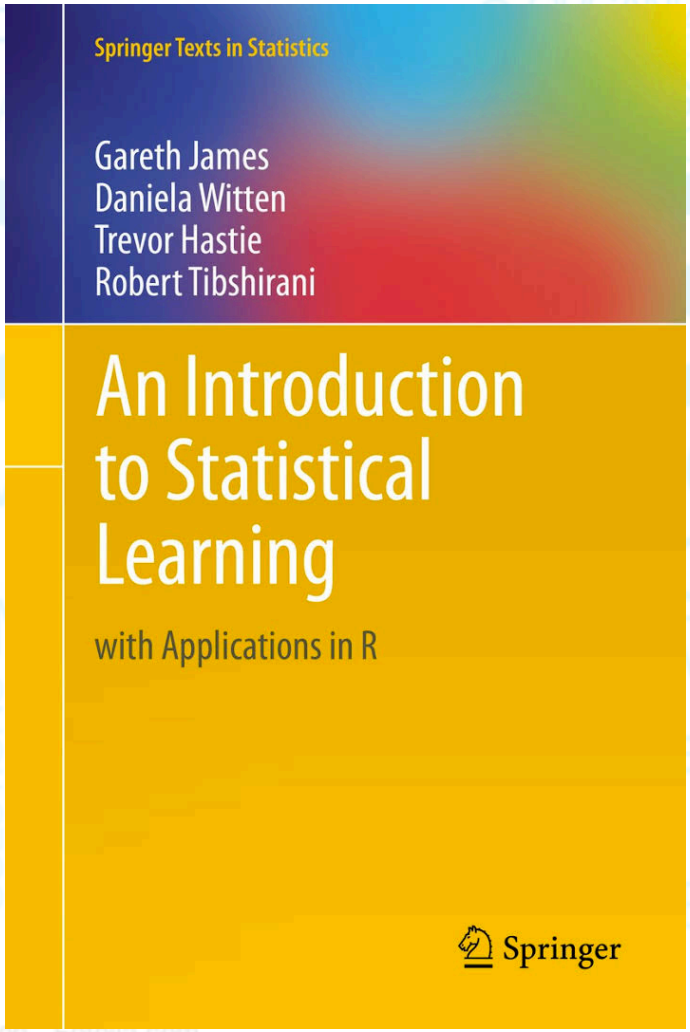
Textbooks (recommended)





Other selected data science books

Machine Learning



Visualization