

Contents

Foreword *xv*

Preface *xvii*

1	We Need An Entrepreneurial Culture in Chemistry: Do You Have What It Takes to be a Chemistry Entrepreneur?	1
	<i>Frank L. Jaksch</i>	
1.1	Introduction: Disruptive Innovation in Chemistry is in High Demand	1
1.2	Examples of Innovation in Chemistry Catching the Eye of the Mainstream Market	2
1.2.1	Food and Nutrition	2
1.2.1.1	Just (formerly Hampton Creek)	2
1.2.1.2	Impossible Foods	2
1.2.1.3	Perfect Day	2
1.2.1.4	Endless West (formerly Ava Winery)	3
1.2.2	Sustainable/Renewable Chemistry	3
1.2.2.1	Ginkgo Bioworks	3
1.2.2.2	Modern Meadow	3
1.2.2.3	Genomatica	3
1.2.2.4	Zymergen	3
1.2.3	Biotech/Pharma	3
1.2.3.1	Moderna Therapeutics	4
1.2.3.2	Unity Biotechnology	4
1.2.3.3	CRISPR Therapeutics, Intellia Therapeutics, and Editas Medicine	4
1.2.4	Diagnostics	4
1.2.4.1	23andme	5
1.2.4.2	Grail Diagnostics	5
1.2.4.3	Viome	5
1.2.5	Cautionary Tales	5
1.2.5.1	Theranos	5
1.2.5.2	Solazyme (TerraVia)	6
1.3	Unique Challenges for Chemistry Entrepreneurs	6
1.3.1	The Most Important Trait of Every Chemical Entrepreneur	7

1.3.2	Chemistry Accelerators, Incubators, and Academic Spin-offs	9
1.3.3	Do Something, do Anything, even if it is Wrong	10
1.3.3.1	Penicillin	10
1.3.3.2	Post-It	11
1.3.3.3	Saccharin	11
1.3.3.4	Teflon	11
1.3.3.5	Viagra	12
1.3.4	You have your Discovery; now you need a Patent	13
1.3.4.1	Provisional Patent	13
1.3.4.2	Patent Application	13
1.3.4.3	Patent Prosecution	13
1.3.4.4	Structure of the Patent Claims	13
1.3.4.5	Patent Search and Prior Art	13
1.3.4.6	Publishing Before Patenting	14
1.3.4.7	PCT International Patent	14
1.3.4.8	Protectable Patent Value	14
1.3.4.9	Selecting the Wrong Lawyer for the Job	14
1.4	Invention is Only the Beginning of Creating a Company	15
1.4.1	Know your Role: Founding CEO vs. Founder vs. Inventor	16
1.4.2	Raising Money: Acquiring the Right Money at the Right Time	17
1.4.2.1	Self-funding	18
1.4.2.2	Friends and Family	18
1.4.2.3	Angel Investors	18
1.4.2.4	Accelerators and Incubators	18
1.4.2.5	Debt	18
1.4.2.6	Strategic Investment	19
1.4.2.7	Private Equity	19
1.4.2.8	Venture Capital	19
1.4.2.9	Investment Banks	20
1.4.3	Can you get the idea for Commercialization?	21
1.4.4	When you are Ready to Commercialize, which path do you take?	22
1.4.4.1	Licensing Deal	22
1.4.4.2	Business-to-Business (B2B)	23
1.4.4.3	Business-to-Consumer (B2C)	23
1.5	Do you have the Traits of an Entrepreneur?	24
1.6	Summary: Do You Have What It Takes?	28
	Recommended Readings and References	30
	Author Biography	30
2	Taking Ideas Out of the Lab: Why and When to Start a Company in the Biomedical Field	33
	<i>Miguel Jimenez, Jason Fuller, Paulina Hill, and Robert Langer</i>	
2.1	Introduction	33
2.2	Company Case Studies: Interviews with the Founding Scientists	34
2.2.1	Advanced Inhalation Research: Interview with David Edwards	34

2.2.1.1	<i>Core Technology</i>	34
2.2.1.2	What was the Key Problem and Initial Idea that Sparked the Work?	34
2.2.1.3	Why was it Important to Start Advanced Inhalation Research?	35
2.2.1.4	When was the Technology Ready to Start Advanced Inhalation Research?	35
2.2.1.5	What Lessons Did You Learn Through This Process?	35
2.2.1.6	<i>Current Status</i>	35
2.2.2	Kala Pharmaceuticals: Interview with Justin Hanes	36
2.2.2.1	<i>Core Technology</i>	36
2.2.2.2	What was the Key Problem and Initial Idea that Sparked the Work?	36
2.2.2.3	Why was it Important to Start Kala Pharmaceuticals?	36
2.2.2.4	When was the Technology Ready to Start Kala Pharmaceuticals?	36
2.2.2.5	What Lessons Did You Learn Through This Process?	37
2.2.2.6	<i>Current Status</i>	37
2.2.3	Moderna: Interview with Derrick Rossi	37
2.2.3.1	<i>Core Technology</i>	37
2.2.3.2	What was the Key Problem and Initial Idea that Sparked the Work?	37
2.2.3.3	Why was it Important to Start Moderna?	38
2.2.3.4	When was the Technology Ready to Start Moderna?	38
2.2.3.5	What Lessons Did You Learn Through This Process?	38
2.2.3.6	<i>Current Status</i>	38
2.2.4	Sigilon Therapeutics: Interview with Arturo Vegas	38
2.2.4.1	<i>Core Technology</i>	39
2.2.4.2	What was the Key Problem and Initial Idea that Sparked the Work?	39
2.2.4.3	Why was it Important to Start Sigilon?	39
2.2.4.4	When was the Technology Ready to Start Sigilon?	39
2.2.4.5	What Lessons Did You Learn Through This Process?	40
2.2.4.6	<i>Current Status</i>	40
2.2.5	Suono Bio: Interview with Carl Schoellhammer	40
2.2.5.1	<i>Core Technology</i>	40
2.2.5.2	What was the Key Problem and Initial Idea that Sparked the Work?	40
2.2.5.3	Why was it Important to Start Suono Bio?	40
2.2.5.4	When was the Technology Ready to Start Suono Bio?	41
2.2.5.5	What Lessons Did You Learn Through This Process?	41
2.2.5.6	<i>Current Status</i>	41
2.2.6	Vivtex: Interview with Thomas von Erlach	41
2.2.6.1	<i>Core Technology</i>	41
2.2.6.2	What was the Key Problem and Initial Idea that Sparked the Work?	41
2.2.6.3	Why was it Important to Start Vivtex?	42
2.2.6.4	When was the Technology Ready to Vivtex?	42
2.2.6.5	What Lessons Did You Learn Through This Process?	42
2.2.6.6	<i>Current Status</i>	42
2.3	Why Start a Company?	43
2.3.1	To Have the Largest Impact on Patients	43
2.3.2	To Introduce a New Platform Technology	44

2.3.3	Is Licensing an Alternative?	45
2.3.3.1	Licensing to Existing Companies	46
2.3.3.2	Corporate-sponsored Academic Research	46
2.4	When to Start a Company?	47
2.4.1	Is There Enough In Vivo Validation?	47
2.4.2	Was a Patent Filed?	48
2.4.3	Was a Paper Published?	49
2.5	The Secret Ingredient: Who and What?	51
2.5.1	Who Will Start the Company?	51
2.5.1.1	Seasoned Mentors as Co-founders	52
2.5.1.2	Finding a Great CEO	52
2.5.2	What Will the Company Actually Sell?	53
2.6	Summary: Lessons Learned	54
2.6.1	Lesson 1: Work on a High-impact, Platform Technology	54
2.6.2	Lesson 2: Patent Early and Broadly	54
2.6.3	Lesson 3: Keep the Tech in the Lab as Long as Possible	55
2.6.4	Lesson 4: Must have in vivo Efficacy and Safety	55
2.6.5	Lesson 5: Publish in Top Scientific Journals	55
2.6.6	Lesson 6: Partner with Seasoned Entrepreneurs	55
	Further Reading	57
	Author Biographies	58

3 In Pursuit of New Product Opportunities: Transferring Technology from Lab to Market 61

Alex Duchak

3.1	Introduction	61
3.1.1	Entrepreneurship and Technology Transfer	61
3.1.2	Pursuing Commercial Product/Service Opportunities via Technology Transfer	63
3.1.3	A Model for Entrepreneurship via Technology Transfer	65
3.1.4	Extracting Technologies from Research Institutions	68
3.2	Technology Discovery and Development	69
3.2.1	Origins of Technology	69
3.2.2	Technology Transfer Communication Models	70
3.2.3	Transitioning Technologies into Products	70
3.2.4	Timing Technology with Industry Acceptance	73
3.3	Customer Discovery and Development	76
3.3.1	Origins of Market Demand and Unmet Needs	76
3.3.2	Identifying a Technology's Uses	77
3.3.3	The Value Chain for Target Applications	77
3.3.4	Identifying Stakeholders in the Value Chain	78
3.3.5	Designing Product Experiments	82
3.3.6	Customer Discovery and Validation Model	83
3.3.6.1	Customer Routines Analysis	85

3.4	Case Study: The Naval Research Laboratory's Self-Decontaminating Material	89
3.4.1	The Challenge	90
3.4.2	The Scientist	90
3.4.3	The Problem	90
3.4.4	The Solution	90
3.4.5	The Future of the Technology and Future Applications	91
3.4.6	Technology Background and Advantages	91
3.4.7	Benefits	92
3.4.8	Problem	92
3.4.9	Technical Approach	93
3.4.10	Solution	93
3.4.11	Industrial Safety and Hygiene	96
3.4.12	Healthcare and Pharmaceuticals	97
3.4.13	First Response	98
	Suggested Reading and Resources	101
	Author Biography	101
4	Financing and Business Development for Hard Tech Startups	103
	<i>Bernard Lupien and Andrew Dougherty</i>	
4.1	Introduction	103
4.2	Challenges in Financing Hard Tech Startups	104
4.2.1	Balancing Ambition with Reality	104
4.2.2	Hard Tech Sure Is Not Software	104
4.2.3	Hard Tech Investors Are a Skeptical Bunch	105
4.2.4	What Do You Mean I Will Not Exit for \$1B?	105
4.2.5	Hard Tech Fundraising Dissonance	106
4.3	Fundraising the Right Way	108
4.3.1	What Kind of Investors Should You Raise from?	108
4.3.1.1	Friends and Family	109
4.3.1.2	Angels	109
4.3.1.3	Early-Stage Institutional Venture Capitalists	110
4.3.1.4	Late-Stage Institutional Venture Capitalists	110
4.3.1.5	Corporate Venture Capital	111
4.3.2	Venture Capital Uncovered	112
4.3.2.1	Fund Life	112
4.3.2.2	Return the Fund	112
4.3.2.3	The Mythical 10x and Why It Is Important to You	113
4.3.3	How to Generate Interest from Investors?	114
4.3.3.1	Team	115
4.3.3.2	Differentiated Technology and Customer Value Proposition	115
4.3.3.3	Large Target Market	115
4.3.3.4	Compelling Plan to Build a Business	116
4.4	The Case for Early-Stage Business Development	119

4.4.1.1	Playbook for Early-Stage Business Development	121
4.4.1.2	Getting Started	121
4.4.1.3	Getting to the Finish Line	122
4.4.1.4	Avoiding Common Pitfalls	123
4.5	Summary	125
	Suggested Reading	128
	Author Biographies	128

5 **Battery Entrepreneurship: Gameboard from Lab to Market** 129

Elena V. Timofeeva, John P. Katsoudas, Carlo U. Segre, Alex Duchak, and Thomas Day

5.1	Introduction	129
5.2	Finding a Market Fit for Your Technology	131
5.3	Energy Storage Markets	133
5.3.1	Portable Electronics, Drones, and Medical Devices	134
5.3.2	Grid Energy Storage and Renewable Energy	134
5.3.3	Industrial Batteries and Back-up Power	136
5.3.4	Home Energy Storage	136
5.3.5	Electric Vehicles	137
5.3.5.1	Passenger Cars	137
5.3.5.2	Light Electric Utility Vehicles	137
5.3.5.3	Heavy-duty Utility Vehicles, Trucks, and Buses	138
5.3.6	Other Nascent Energy Storage Markets	138
5.3.7	Airplanes	138
5.3.8	Ships and Boats	139
5.4	Battery Startup Case Studies	139
5.4.1	Boston Power	140
5.4.2	A123 Systems	141
5.4.3	Aquion Energy	143
5.4.4	Tesla	144
5.4.5	Fluidic Energy	145
5.4.6	Envia Systems	146
5.4.7	Alevo	147
5.4.8	SiNode/Nanograf	148
5.4.9	Sakti3	149
5.4.10	Cadenza Innovation	150
5.4.11	24M Technologies	151
5.5	Lessons Learned from the Case Studies	152
5.5.1	Market Challenges	152
5.5.2	Technical Challenges	153
5.5.3	Financial Challenges	154
5.5.4	Team Challenges	154
5.6	Strategies for Startups and Academic Inventors	154
5.6.1	Funding Strategy	155

5.6.2	Strategic Partnerships	158
5.6.3	Intellectual Property (IP) Management Strategy	159
5.6.4	Technology Licensing	162
5.6.5	Press Relations (PR) and Marketing Strategies	162
5.7	Summary	163
	Further Reading	165
	Author Biographies	165
6	Growing a Business in the Chemical Industry	169
	<i>Michael Lefenfeld</i>	
6.1	Introduction	169
6.2	Strategic Market Segmentation	172
6.2.1	Do I Have a Solution to an Existing Problem or a Solution Looking for a Problem?	173
6.2.2	A Solution Looking for a Problem	174
6.2.3	A Problem Looking for a Solution	175
6.2.4	The Opportunity Matrix: A Roadmap for Scaling a Chemical Business	177
6.2.5	Find the Right Niche	180
6.2.6	Sometimes a Pivot Strategy Can Work	182
6.2.7	Select the Best Path to Market	183
6.2.8	Licensing vs. Manufacturing	184
6.2.9	Strategic Market Assessment	186
6.3	Building Economies of Scale	189
6.3.1	Gaining Customer Traction	190
6.3.2	Customer Testimonials	191
6.3.3	Pricing Models	191
6.3.4	Market Entry and Initial Sales	192
6.3.5	Focus on Measured Growth	193
6.3.6	Direct Sales vs. Distributors	193
6.3.7	Testing and Pivoting	194
6.4	Growing to Commercial Scale	196
6.4.1	Best Practices	196
6.4.2	Financing	197
6.4.3	Growth Constraints	199
6.4.4	Primary and Secondary Markets	199
6.4.5	Insource vs. Outsource	200
6.4.6	Growing Too Fast	201
6.4.7	Hidden Landmines	203
6.4.8	Overcoming Competitive Threats	203
6.4.9	Case Study	205
6.4.9.1	ActiveEOR for the CHOPS Oil Sector	205
6.4.9.2	New Market Strategy	206
6.4.9.3	Introducing a New Chemical to the Oil Market	206
6.4.9.4	Proof of Concept	207

6.5	Summary	208
	Suggested Reading	211
	Author Biography	211
7	New Models to Foster Big Pharma and Chemistry Entrepreneurship	213
	<i>Antonio Gómez</i>	
7.1	Introduction	213
7.2	Setting the Stage	214
7.3	Big Pharma and the Open Innovation Model	216
7.3.1	Universities/Research Institutions	218
7.3.2	Biotech Companies	219
7.3.3	Venture Capital	219
7.3.4	Patient Associations and Charities	220
7.3.5	Public Administrations	221
7.3.6	Contract Research Organizations (CROs)	221
7.4	Considerations for Would-Be Entrepreneurs	222
7.4.1	General Reflections on Collaborations with Big Pharma (the How)	222
7.4.2	Areas of Collaboration Between Chemical Companies and Big Pharma (the What)	225
7.4.2.1	Compound Providers: Custom Synthesis	225
7.4.2.2	Medicinal Chemistry-Based Biotechs	228
7.4.2.3	Cheminformatics-Based Startups	228
7.4.2.4	Getting Information from X-ray Diffraction Studies	229
7.4.2.5	Other Areas	230
7.4.3	Getting in Touch (the Where)	231
7.5	Novel Business Models	232
7.6	Case Study: JJI and the I2D2 Initiative	235
7.7	Summary	237
	Author Biography	240
8	The Economic Need for Chemically Based Start-Up Companies	241
	<i>Daniel Daly</i>	
8.1	Introduction	241
8.2	Promising Programs	244
8.2.1	NSF's I-Corps (Innovation Corps) Program	244
8.2.2	I-Corps Teams or National Cohorts	246
8.2.3	I-Corps Sites	249
8.2.4	I-Corps Nodes	249
8.2.5	Case Study	249
8.2.6	Non-dilutive Funding Opportunities	250
8.2.7	Angel Funding: Dilutive Funding	252
8.2.8	Accelerators	252
8.3	Other Potential Programs	253

8.3.1	Case Studies	256
8.3.1.1	Evotec	256
8.3.1.2	CatSci	256
8.3.2	Agile Innovation Teams	257
8.3.3	Case Studies	257
8.3.3.1	525 Solutions, Inc.	257
8.3.3.2	ThruPore Technologies	259
8.4	Summary	260
	Recommended Reading	262
	Author Biography	262
	Index	263