Gene, Cell, & RNA Therapy Landscape

Q2 2022 Quarterly Data Report

Q2 2022

American Society of Gene + Cell Therapy

Pharma Intelligence
Informa

About the authors

The American Society of Gene & Cell Therapy (ASGCT) is the primary professional membership organization for scientists, physicians, patient advocates, and other professionals with interest in gene and cell therapy.

Our members work in a wide range of settings including universities, hospitals, government agencies, foundations, biotechnology and pharmaceutical companies. ASGCT advances knowledge, awareness, and education leading to the discovery and clinical application of gene and cell therapies to alleviate human disease to benefit patients and society.

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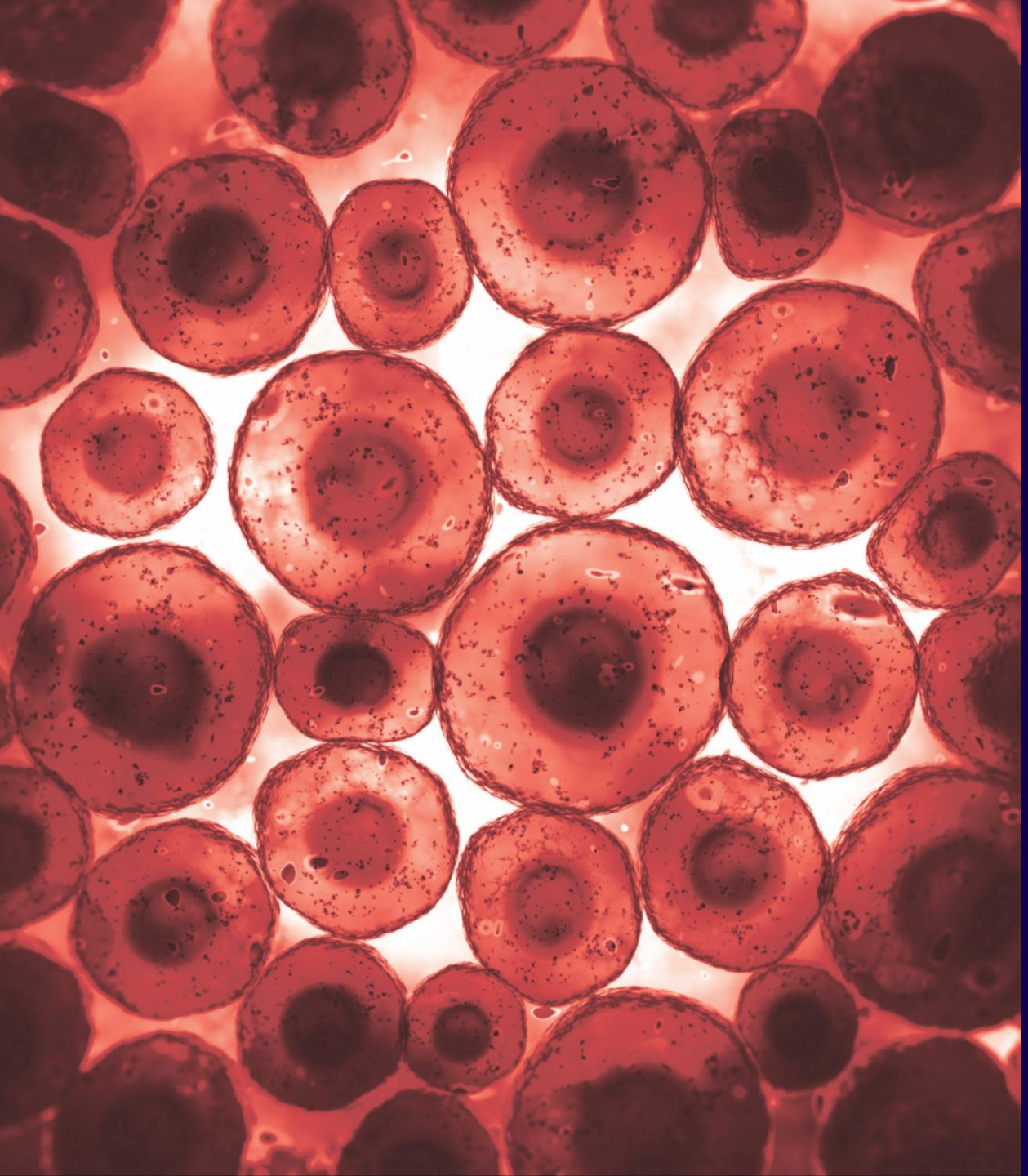

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American Society of Gene + Cell Therapy

Introduction

Welcome to the latest quarterly report from ASGCT and Informa Pharma Intelligence. This quarter, a gene therapy for epidermolysis bullosa awaits approval in the U.S. and a CAR T-cell therapy for multiple myeloma awaits approval in China. The RNA pipeline grew by 4% since Q1, with rare disease and anti-infective indications being the most targeted areas by RNA therapies. The second quarter also saw a strong increase in start-up funding.

There are currently 3,633 therapies in the pipeline—55% are gene, 22% are non-genetically modified cell, and 23% are RNA—from preclinical through pre-registration. In the gene therapy pipeline and in the clinic, oncology and rare diseases remain the top areas of development. For the first time since mid-2021, the number of gene therapies in phase I has increased, rising by 4% since last quarter. In the cell therapy pipeline, COVID-19 complications replaced acute respiratory distress syndrome as the most targeted disease. Q2 saw an increase in messenger RNA, RNA interference, and oligonucleotide therapies. Similar to the previous three quarters, 98% of CAR T-cell therapies are in development for cancer indications.

In Q2, 17 startups raised $793.3 million in seed/Series A funding—an increase in volume and value over the previous quarter. Deal volume was down 20% from the first quarter and nine acquisitions took place. In total there are 19 gene therapies, 59 non-genetically modified cell therapies, and 18 RNA therapies approved for clinical use.

Key takeaways from Q2 2022

No new gene therapies were approved in Q2 2022, however two therapies filed for approval

- beremagene geperpavec, a HSV-1 gene therapy developed by Krystal Biotech, awaits approval in the U.S. for epidermolysis bullosa
- equecabtagene autoleucel, an autologous anti-BCMA-targeting CAR-T therapy developed by Nanjing Iaso Biotherapeutics and Innovent Biologics, await approval in China for multiple myeloma

The RNA pipeline landscape has grown by 4% since Q1 2022

- Growth was seen in all of the most common modalities except for antisense oligonucleotides which remained the same as in the previous quarter
- Rare disease and anti-infective indications are the two most targeted therapeutic areas by RNA therapies

Q2 2022 sees strong increase in start-up funding

- For the first time in several quarters, volume and value of combined seed and Series A financing increased, with 17 companies raising nearly $800M
- Tessa Therapeutics led start-up financing with a $126M Series A round to develop allogeneic CAR-T therapies against CD30-positive cancers
- A decline in alliances led to a 20% drop in overall deal volume compared with Q1, but acquisitions were slightly up, and financings experienced only a small decline

Key highlights in Q2 2022

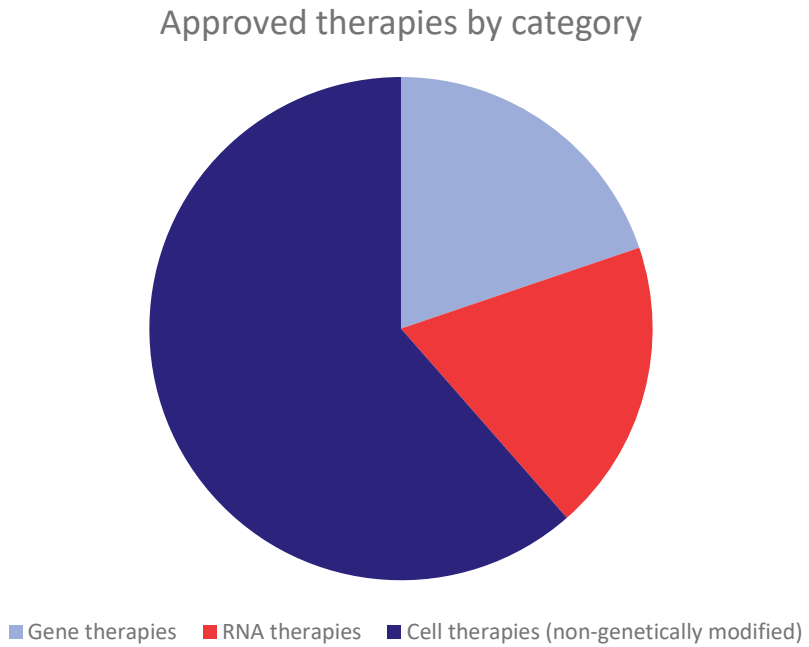
Q2 2022

American Society of Gene + Cell Therapy

Approved gene, cell, and RNA therapies

Globally, for clinical use, there are:

- 19 gene therapies are approved (including genetically modified cell therapies)
  - No new gene therapies were approved since Q1 2022
- 18 RNA therapies are approved
- 59 non-genetically modified cell therapies are approved



Source: Pharmaprojects | Informa, July 2022

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Approved gene therapies as of Q2 2022 (1/2)

Product name	Generic name	Year first approved	Disease(s)	Locations approved	Originator company
Gendicine	recombinant p53 gene	2004	Head and neck cancer	China	Shenzhen SiBiono GeneTech
Oncorine	E1B/E3 deficient adenovirus	2005	Head and neck cancer; nasopharyngeal cancer	China	Shanghai Sunway Biotech
Rexin-G	mutant cyclin-G1 gene	2006	Solid tumors	Philippines	Epeius Biotechnologies
Neovasculgen	vascular endothelial growth factor gene	2011	Peripheral vascular disease; limb ischemia	Russian Federation, Ukraine	Human Stem Cells Institute
Imlygic	talimogene laherparepvec	2015	Melanoma	US, EU, UK, Australia	Amgen
Strimvelis	autologous CD34+ enriched cells	2016	Adenosine deaminase deficiency	EU, UK	Orchard Therapeutics
Kymriah	tisagenlecleucel-t	2017	Acute lymphocytic leukemia; diffuse large B-cell lymphoma; follicular lymphoma	US, EU, UK Japan, Australia, Canada, South Korea	Novartis
Luxturna	voretigene neparvovec	2017	Leber's congenital amaurosis; retinitis pigmentosa	US, EU, UK, Australia, Canada, South Korea	Spark Therapeutics (Roche)
Yescarta	axicabtagene ciloleucel	2017	Diffuse large B-cell lymphoma; non-Hodgkin's lymphoma; follicular lymphoma	US, EU, UK, Japan, Canada, China	Kite Pharma (Gilead)
Collategene	beperminogene perplasmid	2019	Critical limb ischemia	Japan	AnGes
Zolgensma	onasemnogene abeparvovec	2019	Spinal muscular atrophy	US, EU, UK, Japan, Australia, Canada, Brazil, Israel, Taiwan, South Korea	Novartis
Zynteglo	betibeglogene autotemcel	2019	Transfusion-dependent beta thalassemia	EU, UK	Bluebird Bio
Tecartus	brexucabtagene autoleucel	2020	Mantel cell lymphoma; acute lymphocytic leukemia	US, EU, UK	Kite Pharma (Gilead)
Libmeldy	atidarsagene autotemcel	2020	Metachromatic Leukodystrophy	EU, UK	Orchard Therapeutics
Breyanzi	lisocabtagene maraleucel	2021	Diffuse large B-cell lymphoma; follicular lymphoma	US, Japan, EU, UK, Canada	Celgene (Bristol Myers Squibb)

Source: Pharmaprojects | Informa, July 2022

Text highlighted in yellow represent new approvals during Q2 2022

Approved gene therapies as of Q2 2022 (2/2)

Product name	Generic name	Year first approved	Disease(s)	Locations approved	Originator company
Abecma	idecabtagene vicleucel	2021	Multiple myeloma	US, Canada, EU, UK, Japan	bluebird bio
Delytact	teserpaturev	2021	Malignant Glioma	Japan	Daiichi Sankyo
Relma-cel	relmacabtagene autoleucel	2021	Diffuse large B-cell lymphoma	China	JW Therapeutics
Carvykti	ciltacabtagene autoleucel	2022	Multiple myeloma	US, EU, UK	Legend Biotech

Source: Pharmaprojects | Informa, July 2022

Text highlighted in yellow represent new approvals during Q2 2022

Approved RNA therapies as of Q2 2022 (1/2)

Product name	Generic name	Year first approved	Disease(s)	Locations approved*	Originator company
Kynamro	mipomersen sodium	2013	Homozygous familial hypercholesterolemia	US, Mexcio, Argentina, South Korea	Ionis Pharmaceuticals
Exondys 51	eteplirsen	2016	Dystrophy, Duchenne muscular	US	Sarepta Therapeutics
Spinraza	nusinersen	2016	Muscular atrophy, spinal	US, EU, UK, Canada, Japan, Brazil, Switzerland, Australia, South Korea, China, Argentina, Colombia, Taiwan, Turkey	Ionis Pharmaceuticals
Ampligen	rintatolimod	2016	Chronic fatigue syndrome	Argentina	AIM ImmunoTech
Tegsedi	inotersen	2018	Amyloidosis, transthyretin-related hereditary	EU, UK, Canada, US, Brazil	Ionis Pharmaceuticals
Onpattro	patisiran	2018	Amyloidosis, transthyretin-related hereditary	US, EU, UK, Japan, Canada, Switzerland, Brazil, Taiwan, Israel, Turkey	Alnylam
Vyondys 53	golodirsen	2019	Dystrophy, Duchenne muscular	US	Sarepta Therapeutics
Waylivra	volanesorsen	2019	Hypertriglyceridemia; Lipoprotein lipase deficiency	EU, UK, Brazil	Ionis Pharmaceuticals
Comirnaty	tozinameran	2020	Infection, coronavirus, novel coronavirus prophylaxis	UK, Bahrain, Israel, Canada, US, Rwanda, Serbia, United Arab Emirates, Macao, Taiwan, Mexico, Kuwait, Singapore, Saudi Arabia, Chile, Switzerland, EU, Ghana, Colombia, Philippines, Indonesia, Australia, Hong Kong, Peru, South Korea, New Zealand, Japan, Brazil, Sri Lanka, Vietnam, South Africa, Thailand, Oman, Egypt, Malaysia	BioNTech

*For COVID-19 vaccines, this includes emergency use authorization and full approvals

†molnupiravir was previously included in this list, however it has now been removed as it is no longer considered to fall under the category of RNA therapeutics

Source: Pharmaprojects | Informa, July 2022

Text highlighted in yellow represent new approvals during Q2 2022

Approved RNA therapies as of Q2 2022 (2/2)

Product name	Generic name	Year first approved	Disease(s)	Locations approved*	Originator company
Moderna COVID-19 vaccine	COVID-19 vaccine, Moderna	2020	Infection, coronavirus, novel coronavirus prophylaxis	US, Canada, Israel, EU, Switzerland, Singapore, Qatar, Vietnam, UK, Philippines, Thailand, Japan, South Korea, Brunei, Paraguay, Taiwan, Botswana, India, Indonesia, Saudi Arabia, Mexico, Australia, Nigeria, Colombia	Moderna Therapeutics
Givlaari	givosiran	2020	Porphyria	US, EU, UK, Canada, Switzerland, Brazil, Israel, Japan	Alnylam
Oxlumo	lumasiran	2020	Hyperoxaluria	EU, UK, US, Brazil	Alnylam
Viltepso	viltolarsen	2020	Dystrophy, Duchenne muscular	US, Japan	NS Pharma
Leqvio	inclisiran	2020	Atherosclerosis; Heterozygous familial hypercholesterolemia; Hypercholesterolemia	EU, UK, Australia, Canada, Israel, US	Alnylam
Amondys 45	casimersen	2021	Dystrophy, Duchenne muscular	US	Sarepta Therapeutics
Nulibry	fosdenopterin	2021	Molybdenum cofactor deficiency	US	Orphatec
Gennova COVID-19 vaccine	COVID-19 vaccine, Gennova Biopharmaceuticals	2022	Infection, coronavirus, novel coronavirus prophylaxis	India	Gennova Biopharmaceuticals
Amvuttra	vutrisiran	2022	Amyloidosis, transthyretin-related hereditary	US	Alnylam

*For COVID-19 vaccines, this includes emergency use authorization and full approvals

†molnupiravir was previously included in this list, however it has now been removed as it is no longer considered to fall under the category of RNA therapeutics

Source: Pharmaprojects | Informa, July 2022

Text highlighted in yellow represent new approvals during Q2 2022

Key highlights in Q2 2022

Noteworthy events that happened in Q2 2022

Drug	Event Type	Indication	Molecule	Event Date
Breyanzi	Approval (Europe)	Diffuse Large B-Cell Lymphoma (DLBCL) - NHL	Cellular	04/05/2022
Bria-IMT	Fast Track Status	Breast Cancer	Cellular	04/13/2022
ExoFlo	Regenerative Medicine Advanced Therapy (RMAT) Designation	COVID-19 Treatment	Cellular	04/13/2022
ADI-001	Fast Track Status	Diffuse Large B-Cell Lymphoma (DLBCL) - NHL	Cellular	04/19/2022
Viralym-M	Regenerative Medicine Advanced Therapy (RMAT) Designation	Antiviral - Other Treatments	Cellular	04/20/2022
ALLO-605	Orphan Drug Designation (U.S.)	Multiple Myeloma (MM)	Cellular	04/26/2022
AVB-101	Orphan Drug Designation (Europe and U.S.)	Dementia	Viral Gene Therapy	04/27/2022
SQZ-PBMC-HPV	Fast Track Status	Solid Tumors	Cellular	04/27/2022
GPH101	Fast Track Status	Sickle Cell Anemia	Cellular	05/03/2022
Upstaza	CHMP (European Panel) Results (Positive)	Neurology - Other	Viral Gene Therapy	05/19/2022
Etranacogene Dezaparvovec	Priority Review	Hemophilia B	Viral Gene Therapy	05/24/2022
NeoCart	Regenerative Medicine Advanced Therapy (RMAT) Designation	Cartilage and Joint Repair	Cellular	05/24/2022
Carvykti	Conditional Approval (Europe)	Multiple Myeloma (MM)	Cellular	05/26/2022
ION-581	Orphan Drug Designation (U.S.)	Angelman Syndrome	Antisense	05/26/2022
Omidubicel	Rolling NDA/BLA Completed	Bone Marrow Transplant and Stem Cell Transplant	Cellular	06/02/2022
Equecabtagene	Filing for Approval (Emerging Markets)	Multiple Myeloma (MM)	Cellular	06/02/2022
ION-581	Rare Pediatric Disease (RPD) Designation	Angelman Syndrome	Antisense	06/13/2022
MB-106	Orphan Drug Designation (U.S.)	Non-Hodgkin's Lymphoma (NHL)	Cellular	06/16/2022
B-VEC	NDA/BLA Filing	Epidermolysis Bullosa	Viral Gene Therapy	06/22/2022
Roctavian	CHMP (European Panel) Results (Positive)	Hemophilia A	Viral Gene Therapy	06/23/2022
ADVM-022	PRIME Designation (Europe)	Wet Age-Related Macular Degeneration (Wet AMD) (Ophthalmology)	Viral Gene Therapy	06/24/2022

Source: Biomedtracker | Informa, July 2022

Pipeline overview

Q2 2022

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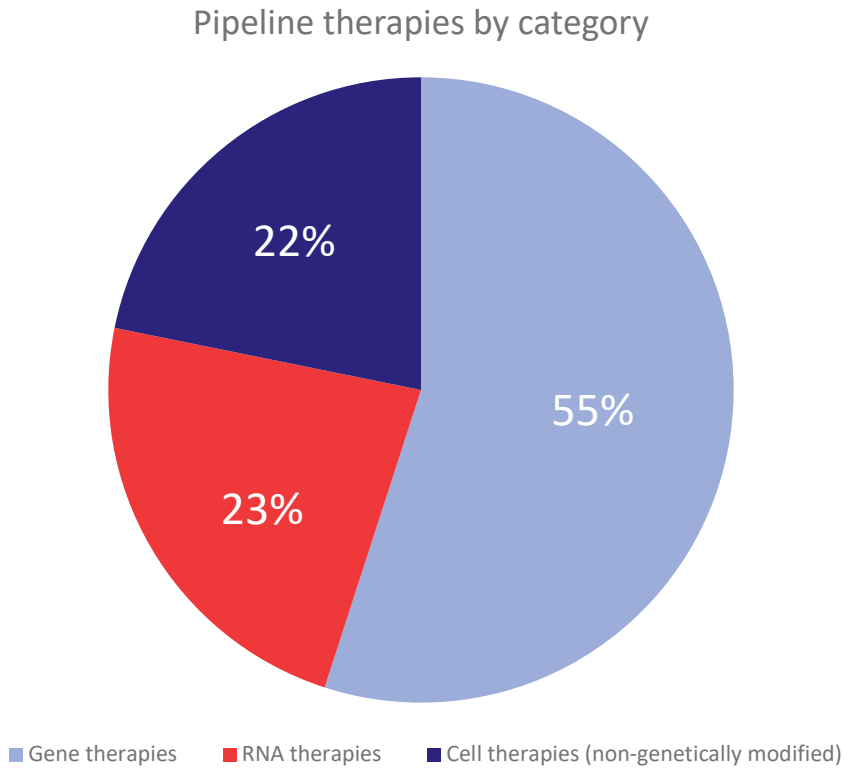
Pipeline of gene, cell, and RNA therapies

3,633 therapies are in development, ranging from preclinical through pre-registration

- 2,024 gene therapies (including genetically-modified cell therapies such as CAR T-cell therapies) are in development, accounting for 55% of gene, cell, and RNA therapies
- 803 non-genetically modified cell therapies are in development, accounting for 22% of gene, cell, and RNA therapies



Source: Pharmaprojects| Informa, July 2022

Gene therapy pipeline

Gene therapy and genetically modified cell therapies

Q2 2022

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Gene therapy pipeline: Quarterly comparison

- For the first time since Q2 2021, the number of gene therapies in Phase I has increased, rising by 4% since Q1 2022
- Two new gene therapies have filed for approval in Q2 2022. Therapies currently in pre-registration:
  - valoctocogene roxaparvovec (BioMarin)
    - In the EU and UK
  - lenadogene nolparvovec (Genethon, GenSight Biologics)
    - In the EU and UK
  - nadofaragene firadenovec (Ferring, FKD Therapeutics, Trizell)
    - In the US
  - eladocagene exuparvovec (PTC Therapeutics)
    - In the EU and UK
  - elivaldogene autotemcel (bluebird bio)
    - In the US
  - etranacogene dezaparvovec (uniQure, CSL Behring)
    - In the EU, UK, and US
  - beremagene geperpavec (Krystal Biotech)
    - In the US
  - equecabtagene autoleucel (Nanjing Iaso Biotherapeutics, Innovent)
    - China

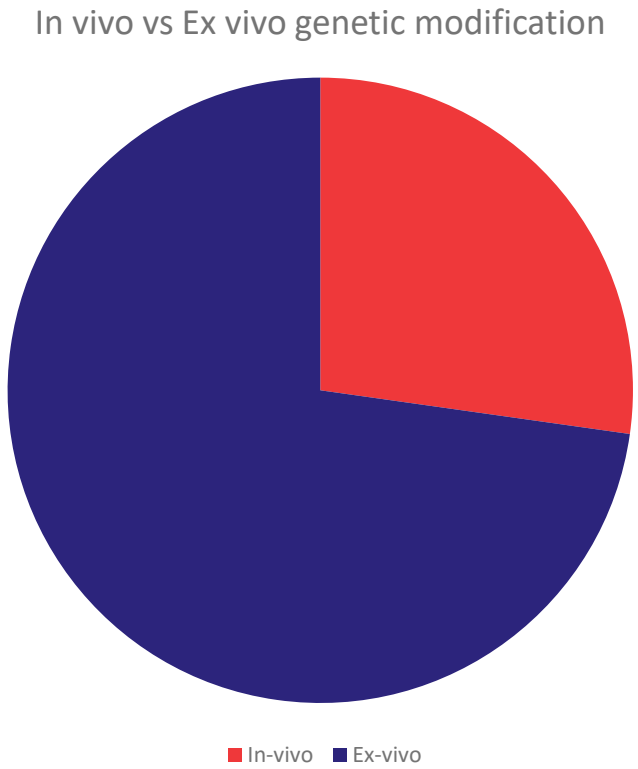
Global Status	Q2 2021	Q3 2021	Q4 2022	Q1 2022	Q2 2022
Preclinical	1,296	1,353	1,412	1,451	1,482
Phase I	269	264	248	248	258
Phase II	236	239	244	250	248
Phase III	27	29	32	31	28
Pre-registration	7	5	5	6	8
Total	**1,835**	**1,890**	**1,941**	**1,986**	**2,024**

Source: Pharmaprojects| Informa, July 2022

 Source: Pharmaprojects | Informa, July 2022

Genetic modification: *In vivo* vs. *Ex vivo*

- Similar to Q1 2022, *ex vivo* genetic modification is more widely used for gene therapies in pipeline development
- In Q2 2022, *in vivo* delivery techniques were used in 27% of gene therapies, the same proportion as in the previous 2 quarters



Source: Cell and Gene Therapy dashboard | Informa, July 2022

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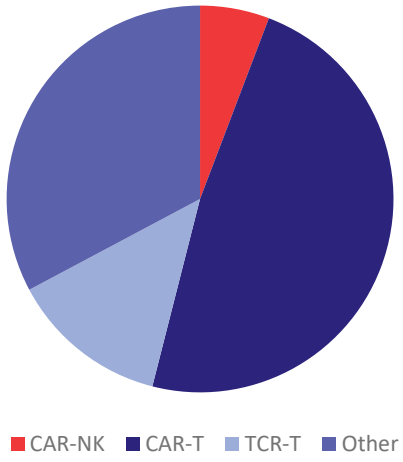
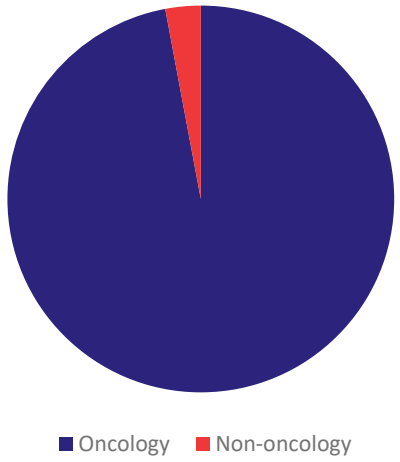
Gene therapy breakdown: CAR-Ts continue to dominate pipeline in Q2 2022

- CAR-T cell therapies continue to be the most common technology used in the pipeline of genetically modified cell therapies (preclinical through to pre-registration), representing 48%, followed by the “other” category at 33%, which includes a list of less commonly used technologies including TCR-NK, CAR-M, and TAC-T
- As found in the previous 3 quarters, 98% of CAR-T cell therapies are in development for cancer indications. The remaining non-oncology indications include scleroderma, HIV/AIDs and autoimmune disease (unspecified)

Genetically modified cell therapy breakdown



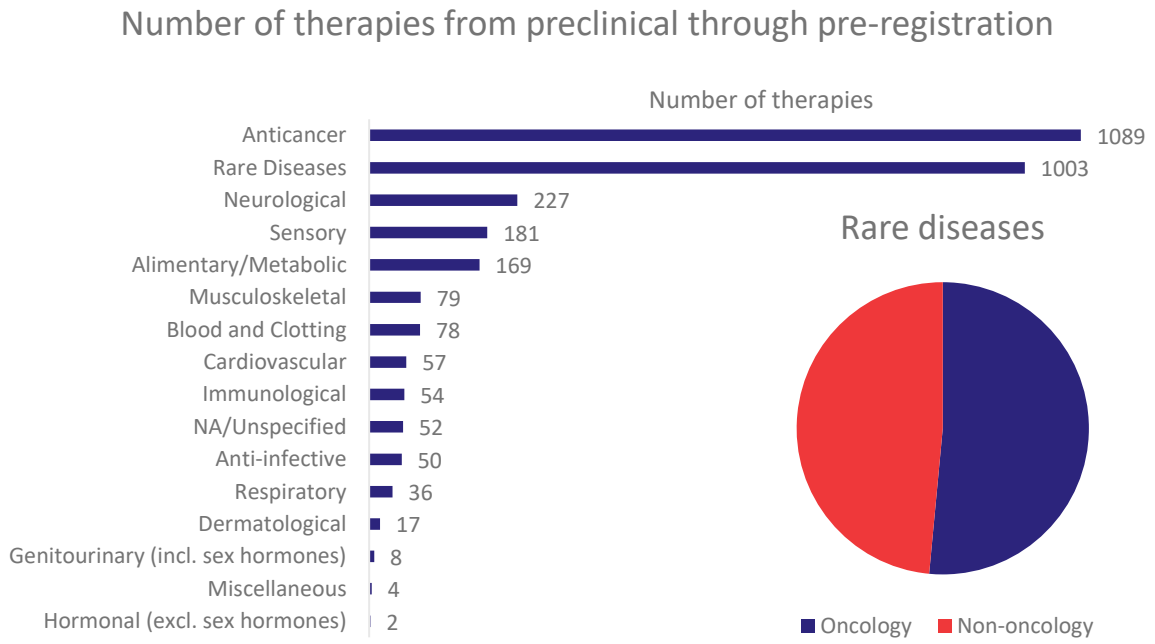
CAR-T breakdown

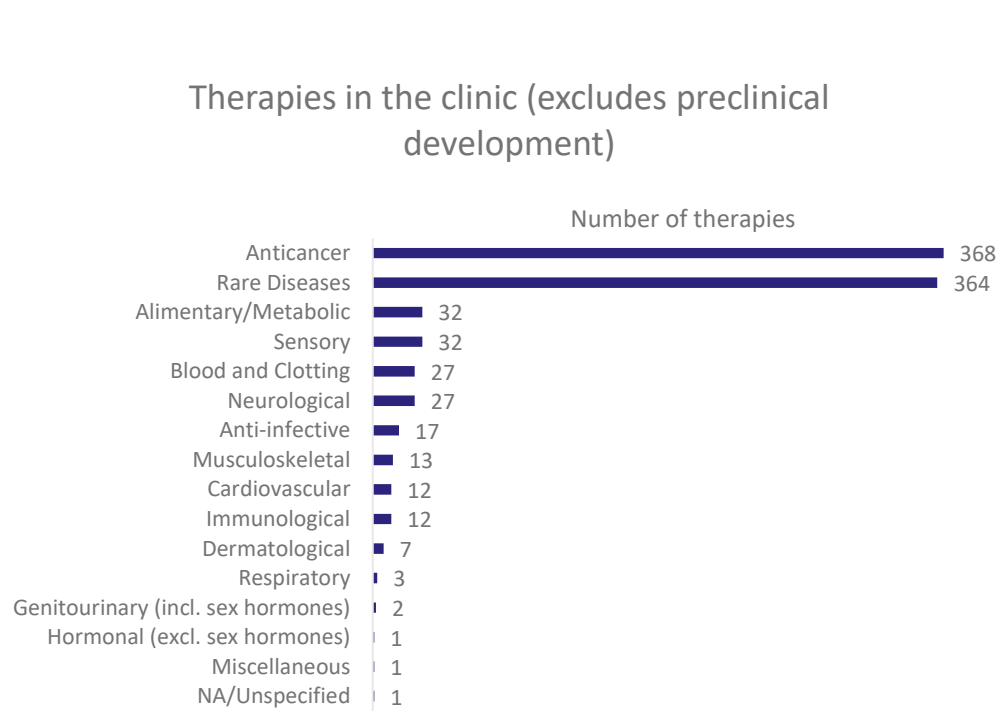


Source: Cell and Gene Therapy dashboard | Informa, July 2022

Gene therapy pipeline: Most commonly targeted therapeutic areas

- Oncology and rare diseases remain the top areas of gene therapy development in both the overall pipeline (preclinical to pre-registration) and in the clinic (phase I to pre-registration), with anticancer therapies overtaking rare disease therapies as the most common therapy type in the clinic since Q1 2022
- Development for rare diseases most commonly occurs in oncology, representing a majority of 52% compared to non-oncology rare disease gene therapy pipeline development, the same proportion as found in Q1 2022





Source: Pharmaprojects| Informa, July 2022

*figures based on indications in pipeline development only for each therapy

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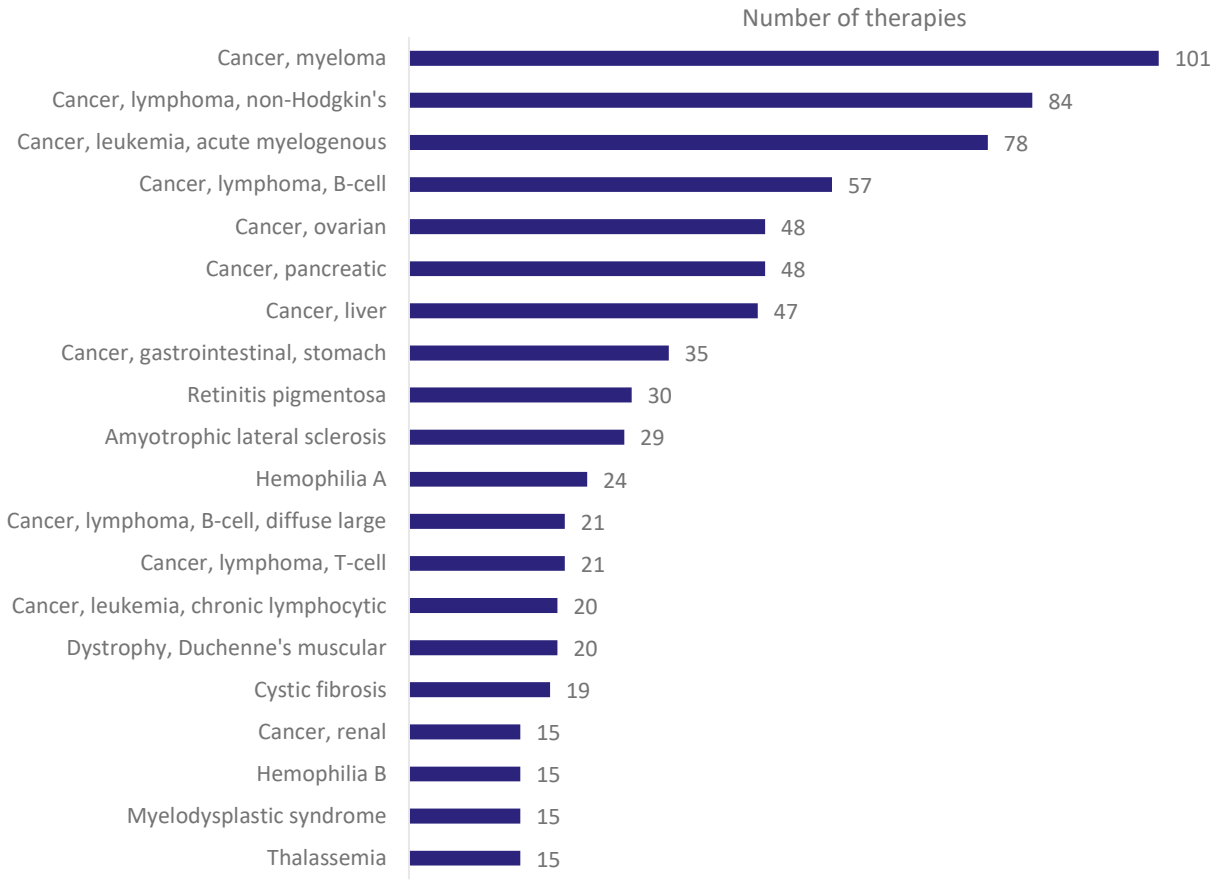
Gene therapy pipeline: Most common rare diseases targeted

- For the 1003 pipeline (preclinical to pre-registration) gene therapies which are being developed for rare diseases, 8 out of the top 10 rare diseases are oncological, as in Q1 2022
- In the same order as the previous 2 quarters, the top 5 rare diseases for which gene therapies are being developed are:
  1. Myeloma
  2. Non-Hodgkin’s lymphoma
  3. Acute myelogenous leukemia
  4. B-cell lymphoma
  5. Ovarian cancer



Source: Pharmaprojects| Informa, July 2022

*figures based on indications in pipeline development only for each therapy

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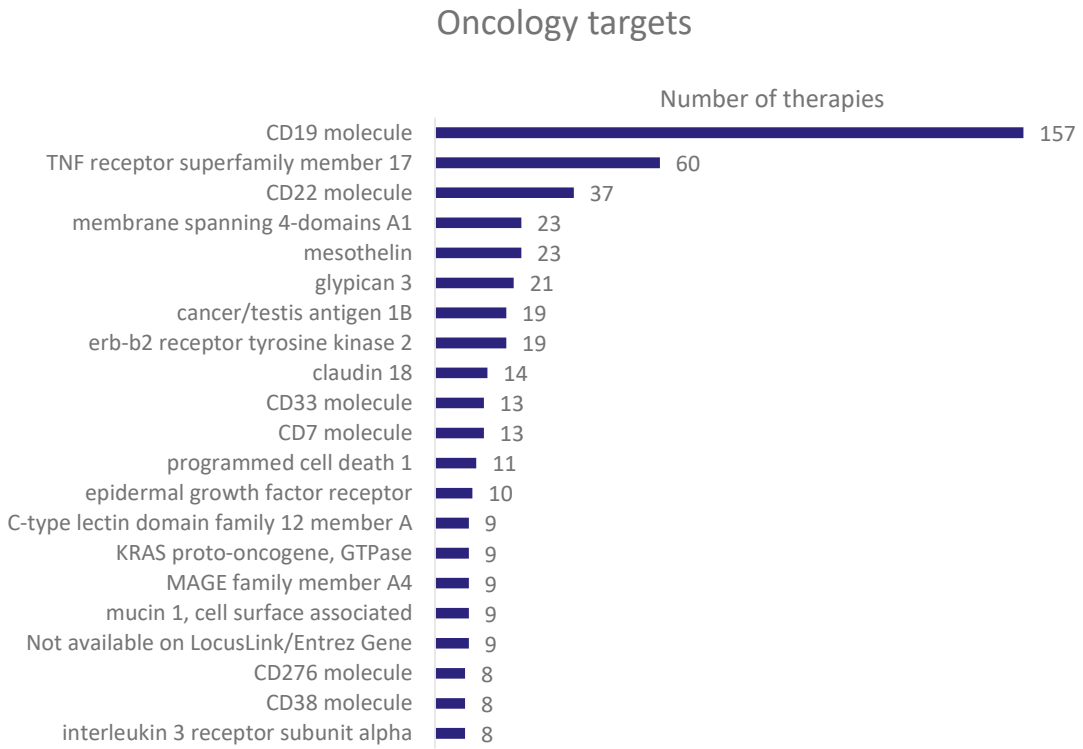
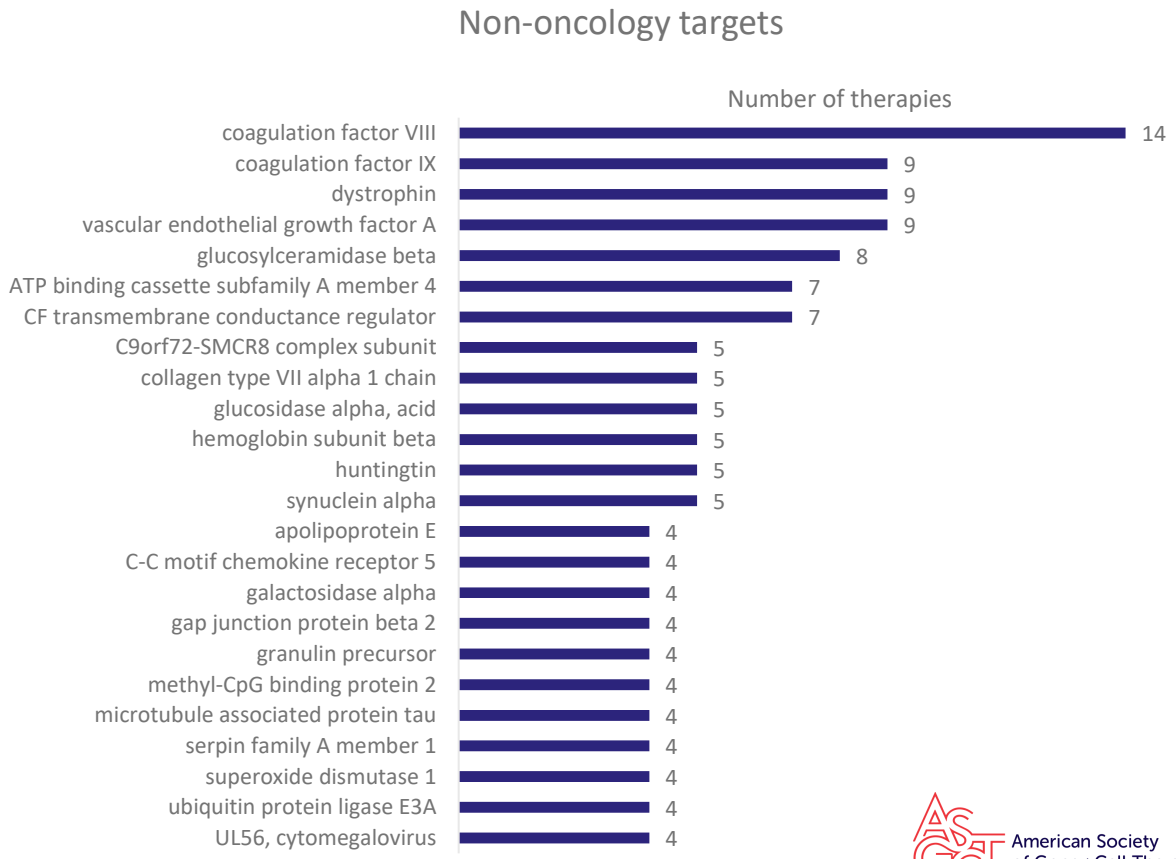
Gene therapy pipeline: Most common targets

Of the gene therapies in preclinical trials through pre-registration in which targets are disclosed:

- CD19, B-cell maturation antigen (BCMA), also known as TNF receptor superfamily member 17, and CD22 molecule continue to be the top 3 most common targets for oncology indications
- Coagulation factor VIII and coagulation factor IX remain the most common targets for non-oncology indications since Q1 2022





Source: Pharmaprojects| Informa, July 2022

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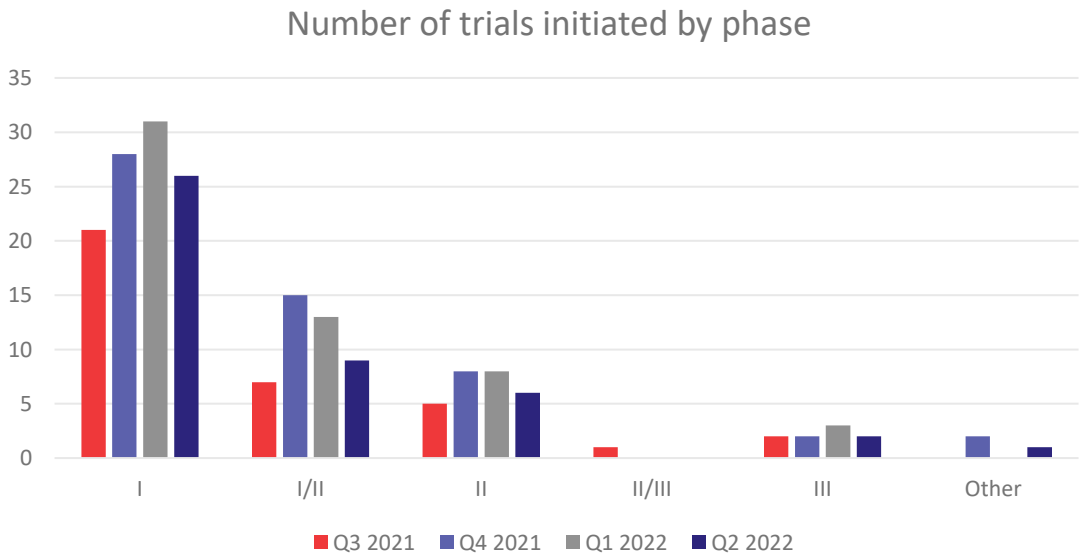
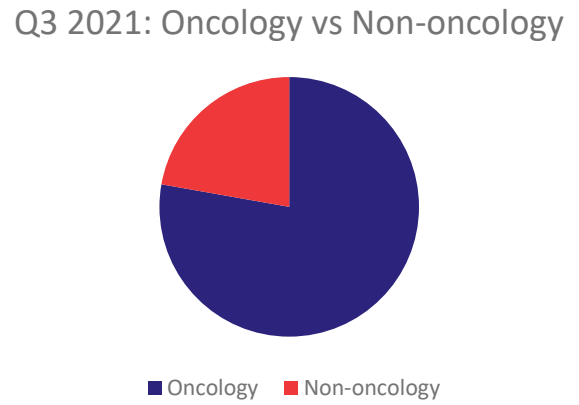
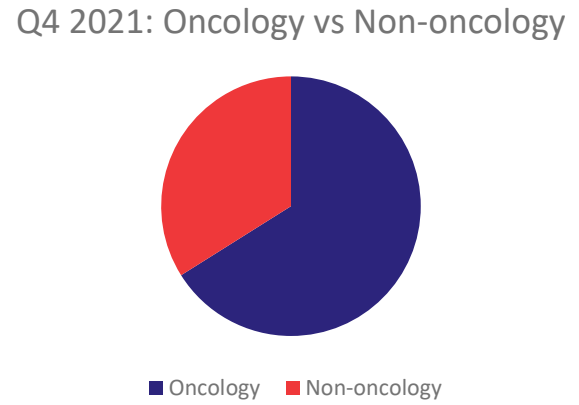
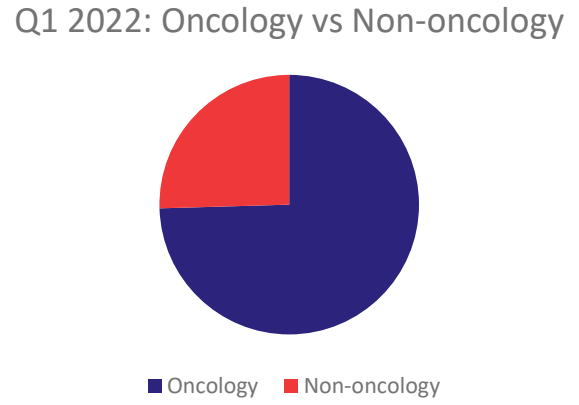
Gene therapy clinical trial activity

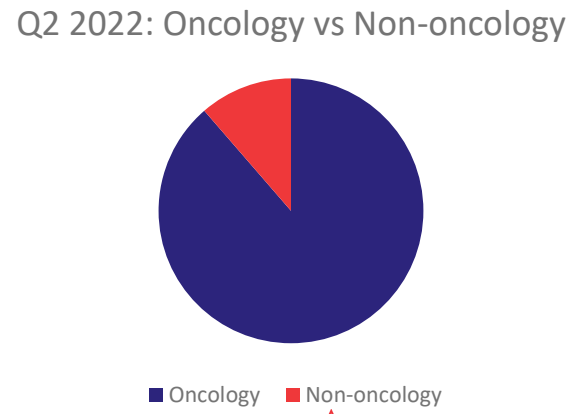
- 44 trials were initiated in Q2 2022 for gene therapies, a drop of 20% since Q1 2022
- The proportion of gene therapy trials for non-oncology indications continues to decrease in 2022 with 11% of the newly initiated trials in Q2 being for non-oncology diseases compared to 25% in Q1











Source: Trialtrove| Informa, July 2022

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Non-genetically modified cell therapy pipeline

Q2 2022

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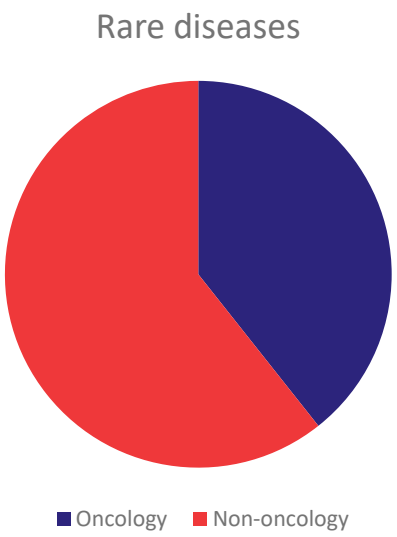
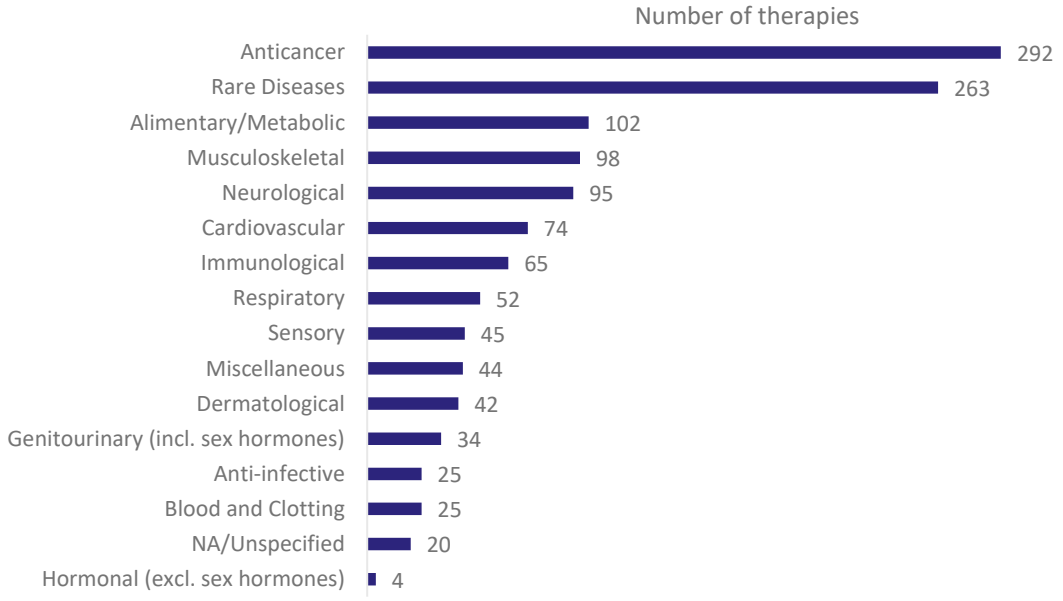
Non-genetically modified cell therapy pipeline: Most common therapeutic areas targeted

Of the cell therapies in development (preclinical through pre-registration):

- Oncology and rare diseases remain the top areas of non-genetically modified cell therapy development
- Of the non-genetically modified cell therapies in preclinical to pre-registration stages for rare diseases, 63% are in development for non-oncology rare diseases, the same proportion as found in Q1 2022





Source: Pharmaprojects| Informa, July 2022

*figures based on indications in pipeline development only for each therapy

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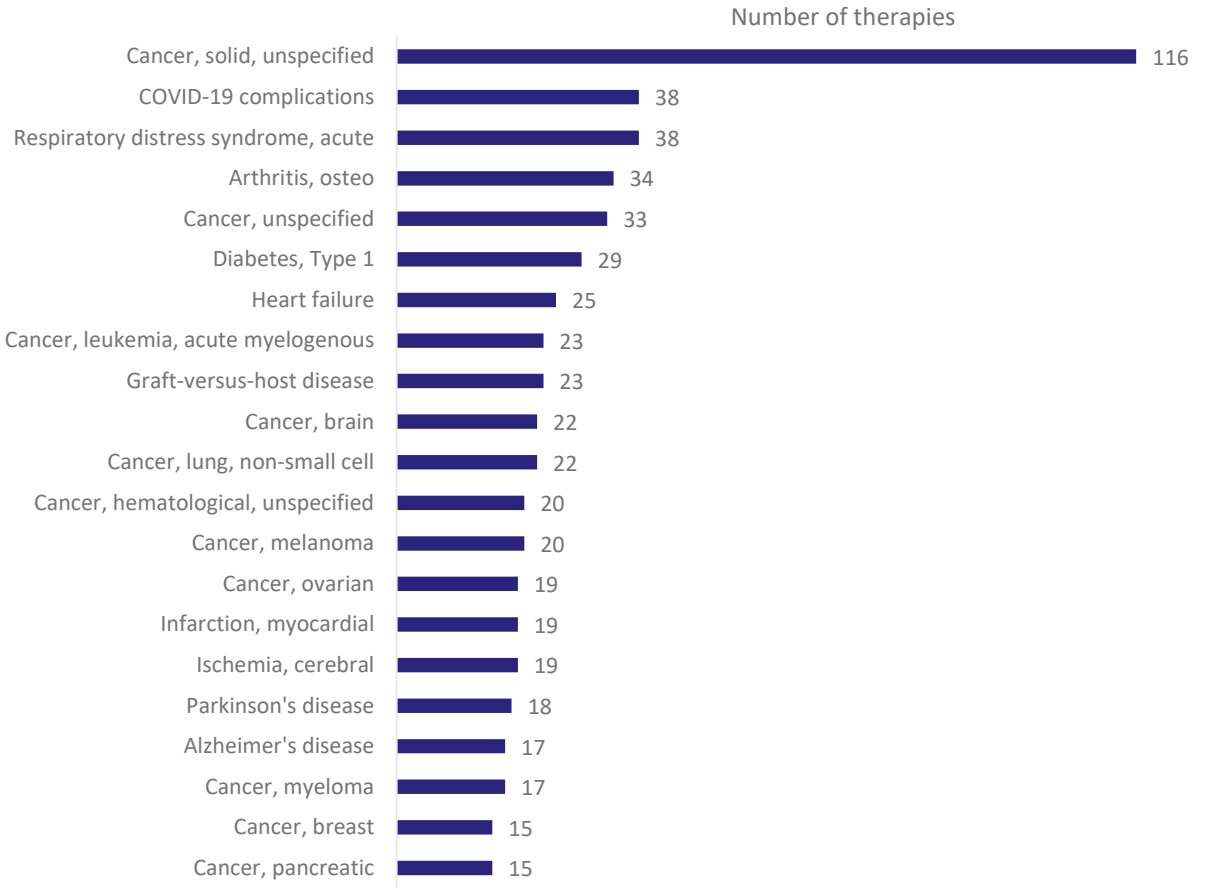
Non-genetically modified cell therapy pipeline: Most common diseases targeted

Of the diseases for which indications are specified, the top three indications remain the same as in Q4 2021 and Q1 2022, with COVID-19 complications replacing acute respiratory distress syndrome as the most targeted in Q2 2022:

1. COVID-19 complications
2. Respiratory distress syndrome
3. Osteo arthritis



Source: Pharmaprojects| Informa, July 2022

*figures based on indications in pipeline development only for each therapy

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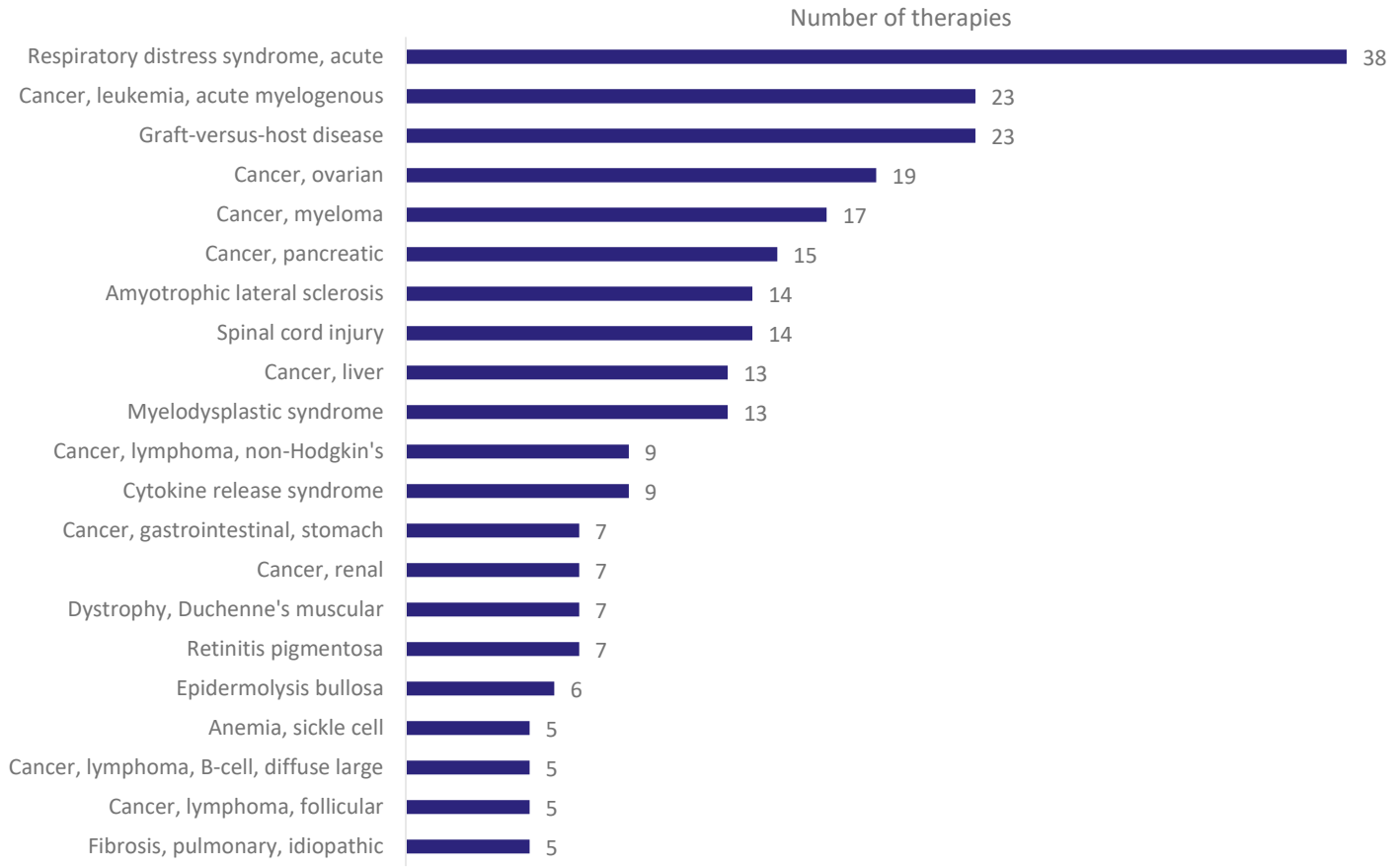
Non-genetically modified cell therapy pipeline: Most common rare diseases targeted

Of the cell therapies in development (preclinical through pre-registration) for rare diseases:

- The top three oncology indications are acute myelogenous leukemia, ovarian cancer, and myeloma
- The top three non-oncology indications remain to be acute respiratory distress syndrome, graft-versus-host disease, and amyotrophic lateral sclerosis



Source: Pharmaprojects| Informa, July 2022

*figures based on indications in pipeline development only for each therapy

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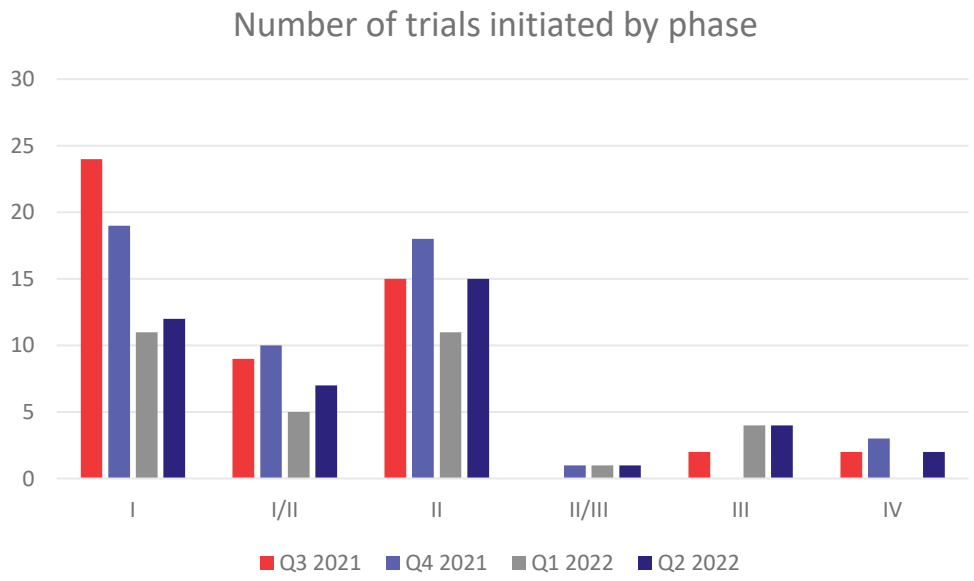
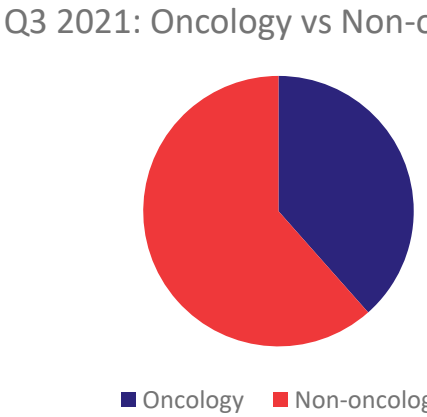
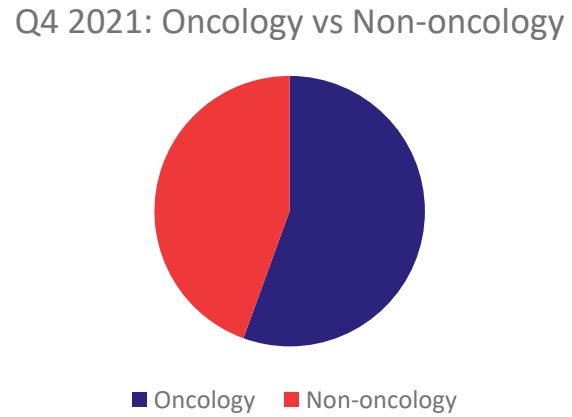
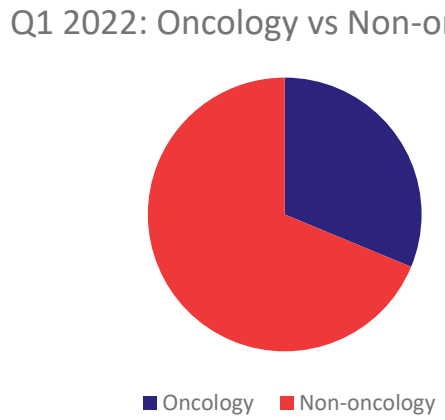
Non-genetically modified cell therapy trial activity

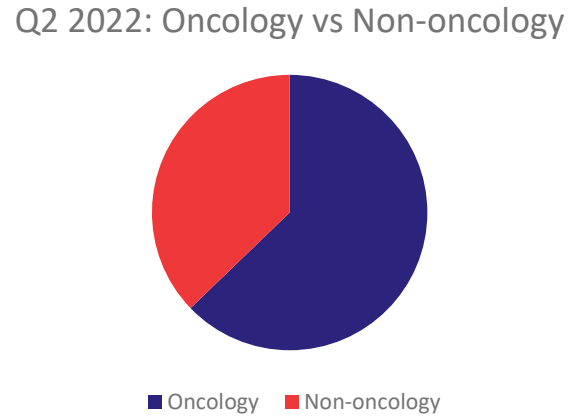
- 41 trials were initiated for non-genetically modified cell therapies in Q2 2022, and of these 39% are for non-oncology indications, a decrease of 30% since Q1 2022











Source: Trialtrove| Informa, July 2022

American Society of Gene + Cell Therapy

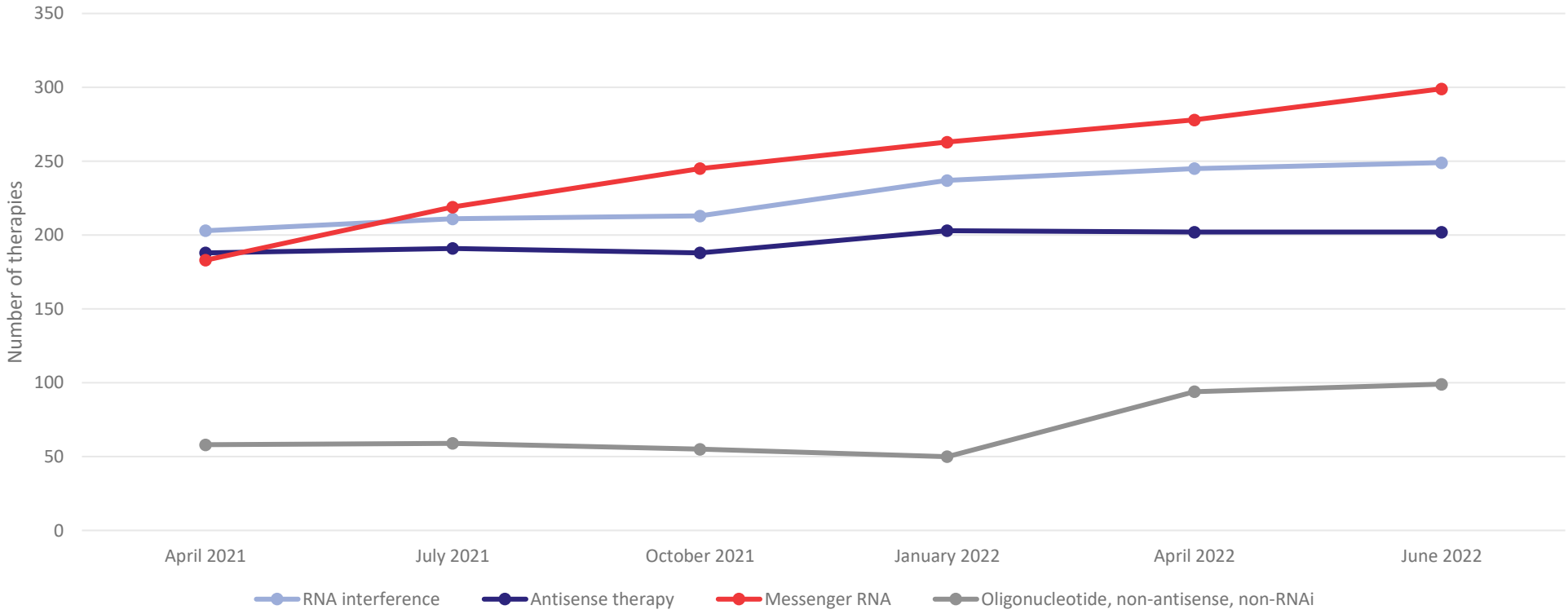
RNA therapy pipeline

Q2 2022

American Society of Gene + Cell Therapy

RNA therapy pipeline: Most common modalities

- Q2 2022 has seen an increase in messenger RNA, RNA interference, and Oligonucleotide (non-antisense, non-RNAi) therapies, while the number of antisense therapies have remained level since Q1 2022 at 202



Source: Pharmaprojects| Informa, July 2022

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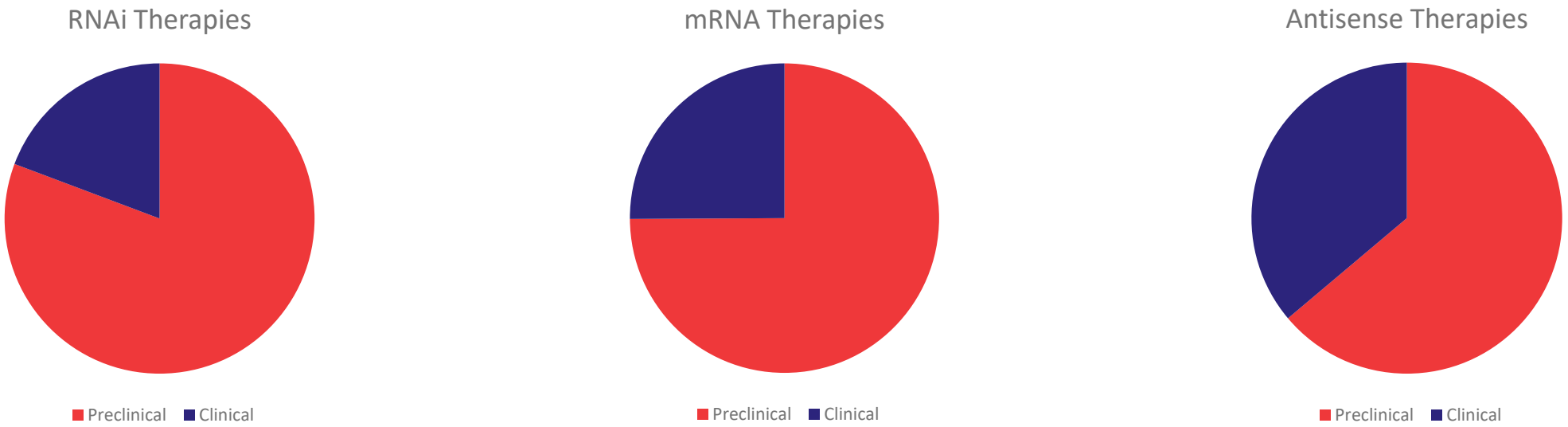
RNAi, mRNA, and antisense oligonucleotides: Preclinical vs. clinical

- Preclinical development continues to dominate RNAi, mRNA, and antisense therapeutic development, representing 81%, 75%, and 64% of development respectively

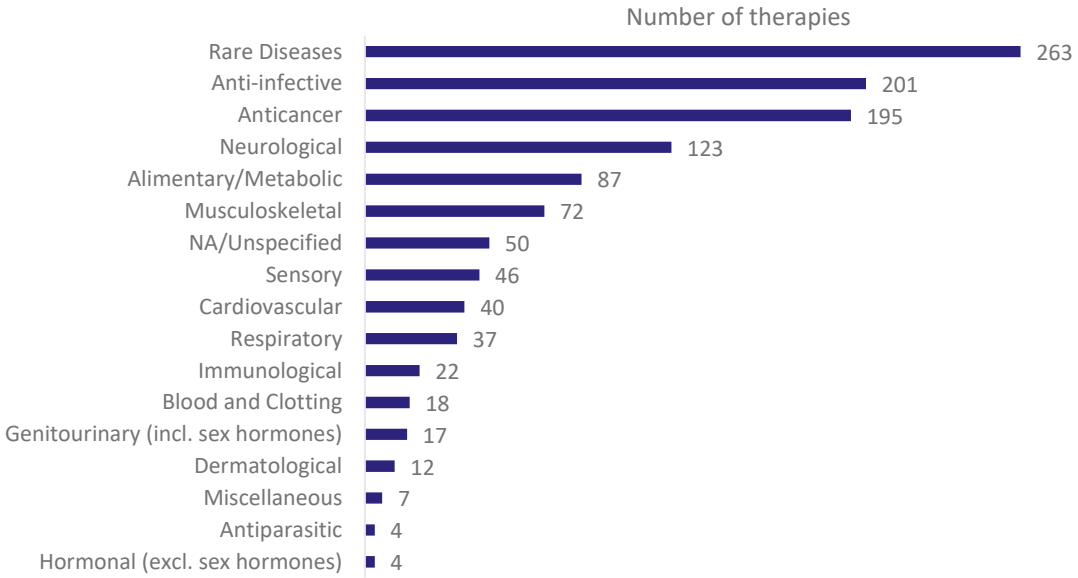


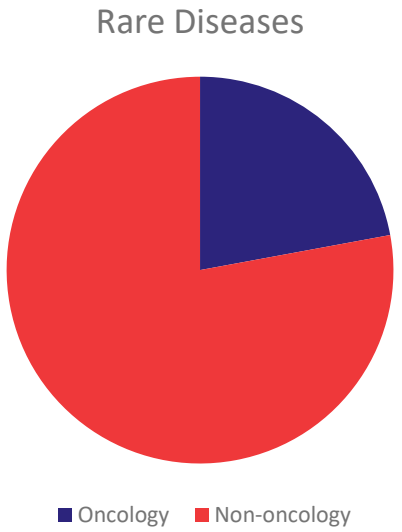
Source: Pharmaprojects| Informa, July 2022

RNA therapies: Most commonly targeted therapeutic areas

Of the 854 RNA therapies currently in the pipeline (from preclinical through pre-registration):

- Rare diseases remain the top targeted therapeutic area by RNA therapies, while anti-infective therapies have returned to be the second most common RNA therapy type, above anticancer therapies
- Non-oncology indications continue to be the most targeted rare diseases by RNA therapies, representing a majority of 79%





Source: Pharmaprojects| Informa, July 2022

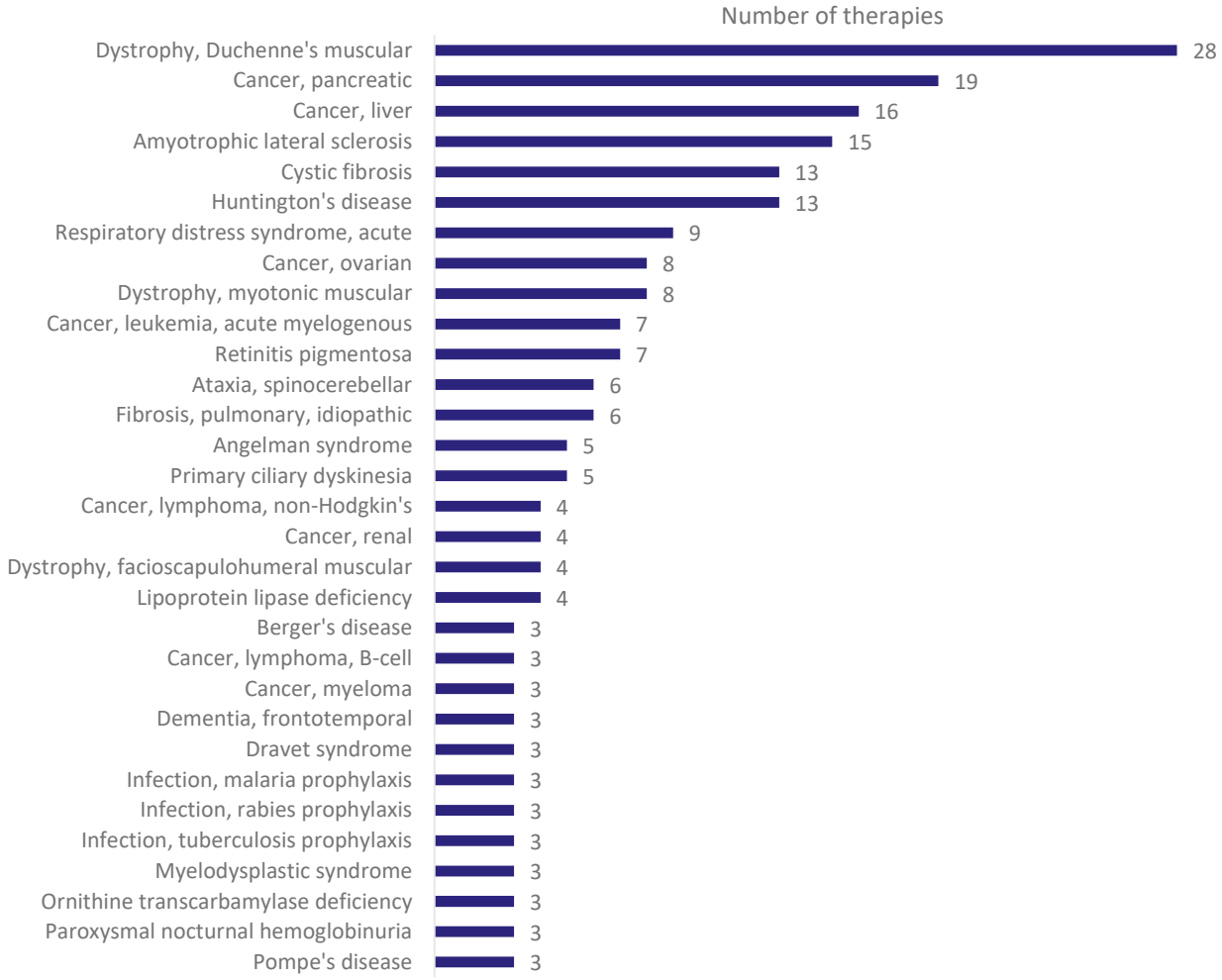
*figures based on indications in pipeline development only for each therapy

American Society of Gene + Cell Therapy

RNA therapies: Most common rare diseases targeted

Of the RNA therapies currently in the pipeline (from preclinical through pre-registration):

- Top specified rare oncology indications are pancreatic, liver, and ovarian cancer, as in Q1 2022
- For non-oncology rare diseases, Duchenne's muscular dystrophy, amyotrophic lateral sclerosis, and cystic fibrosis are the top most commonly targeted indications



Source: Pharmaprojects| Informa, July 2022

*figures based on indications in pipeline development only for each therapy

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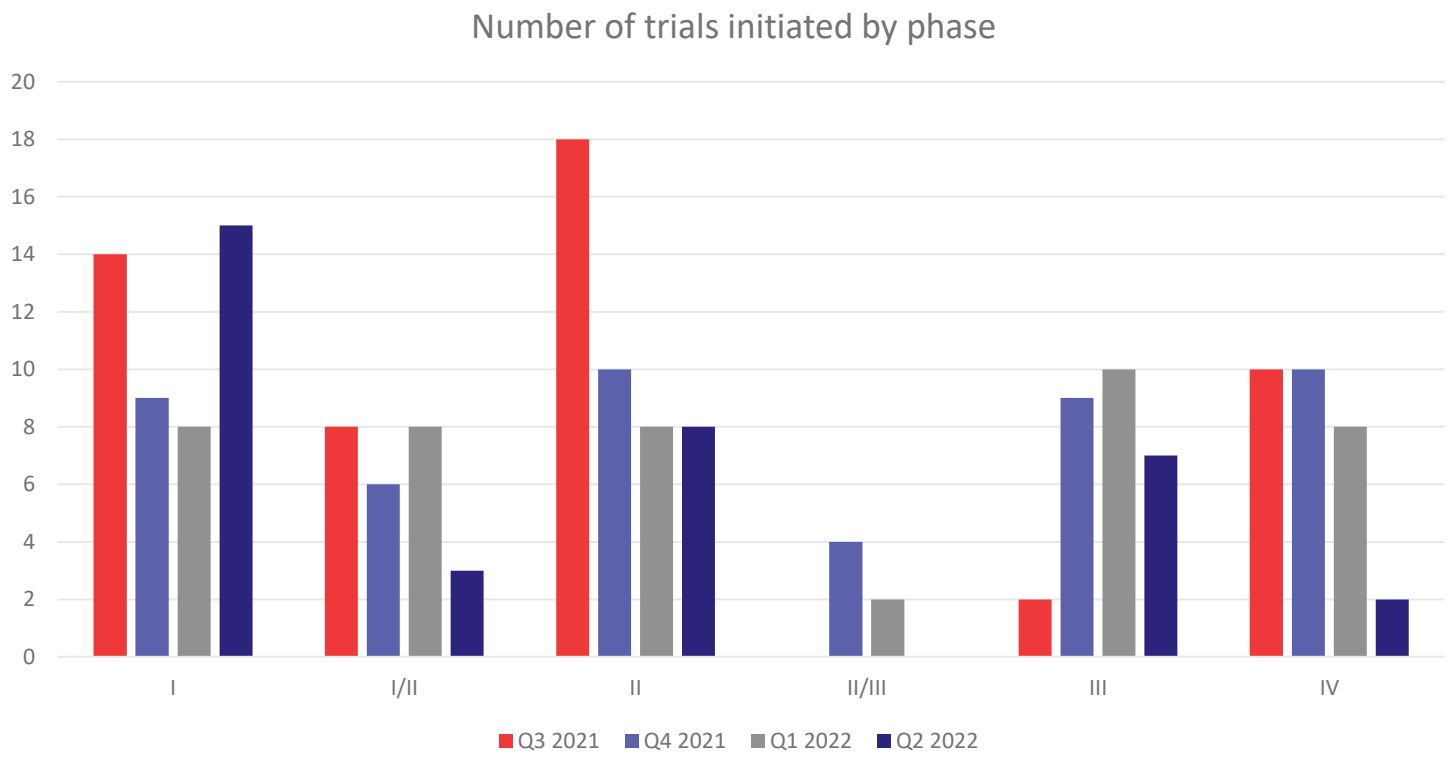
RNA therapy pipeline: Clinical trial activity

- 36 RNA trials were initiated in Q2 2022, compared to 44 in Q1 2022, 92% of which were for non-oncology indications, a decrease of 1% since the previous quarter



Source: Trialtrove| Informa, July 2022

American Society of Gene + Cell Therapy

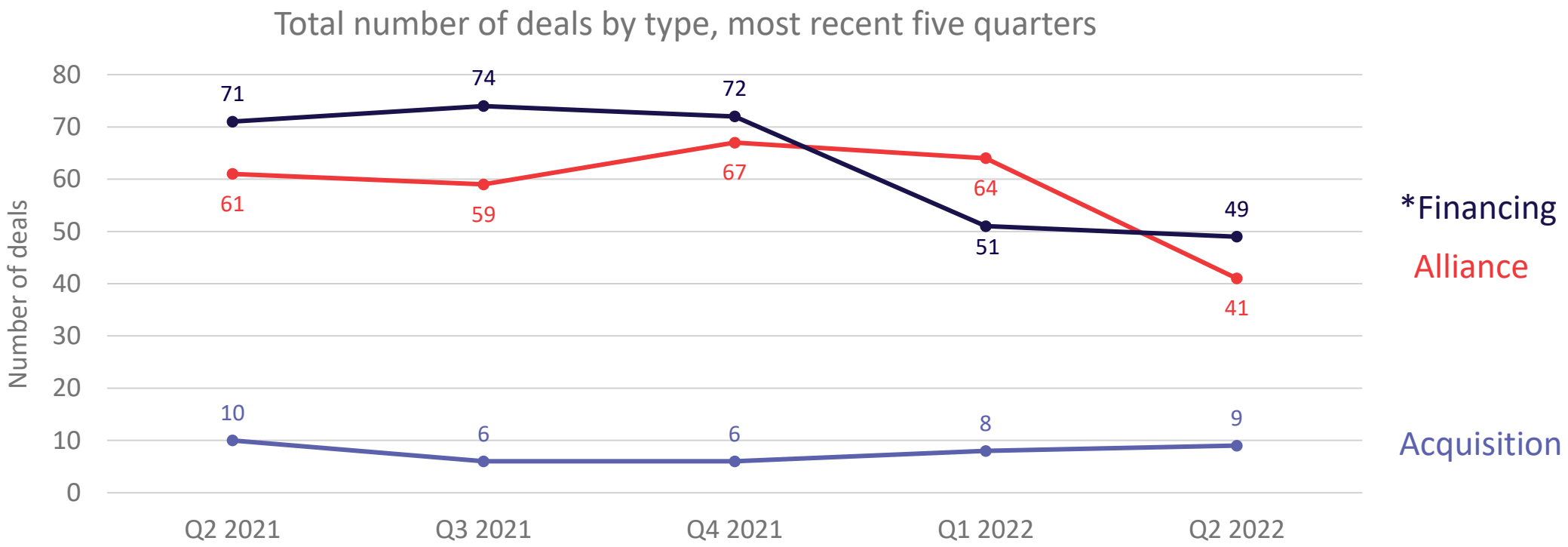
Overview of dealmaking for gene, cell, and RNA therapy companies

Q2 2022

American Society of Gene + Cell Therapy

Alliance, acquisition, and financing in gene, cell, & RNA therapy

- Q2 2022's total deal volume of 99 represented a 20% decrease from Q1's 123 deal aggregate, continuing a trend in the shrinking of overall deal numbers
- The decline in Q2 was due to a 20+ deal drop in alliances; there was also a small decrease in total financings
- Conversely, acquisitions were slightly up from the previous quarter



Source: Biomedtracker| Informa, July 2022

*Financings include public financings (IPOs and follow-ons) plus privately raised funding through venture rounds, debt offerings, or private investment in public equity

American Society of Gene + Cell Therapy

Q2 2022 acquisitions in gene, cell, & RNA therapy

- Nine acquisitions took place in the gene, cell, & RNA sector in Q2, an increase of 1 deal over Q1
- Galapagos moved into the CAR-T market with 2 separate acquisitions, paying $237 million for CellPoint, which aims to develop CAR-T therapies for point-of-care administration; and $14 million for AboundBio to gain access to an automated point-of-care cell therapy supply model

Deal Date	Deal Title	Potential Deal Value (USD, $M)
04/05/2022	Isto Biologics Acquires TheraCell	Undisclosed
04/26/2022	Isleworth Healthcare Acquisition and Cytovia Therapeutics Announce Business Combination to Create Publicly Listed Company*	Undisclosed
05/04/2022	Unchained Labs Acquires NanoView Biosciences	Undisclosed
05/17/2022	GC Corp. Acquires CDMO BioCentriq	73
05/30/2022	Evotec to Acquire Rigenerand	25
06/08/2022	CureVac Acquires Frame Therapeutics	34
06/20/2022	Onward Therapeutics Acquires Emercell	Undisclosed
06/21/2022	Galapagos Acquires AboundBio	14
06/21/2022	Galapagos Acquires CellPoint	237

Source: Biomedtracker| Informa, July 2022

*On June 30, Cytovia and Isleworth Healthcare Acquisition Corp. terminated their merger

Start-up funding for gene, cell, & RNA therapy companies

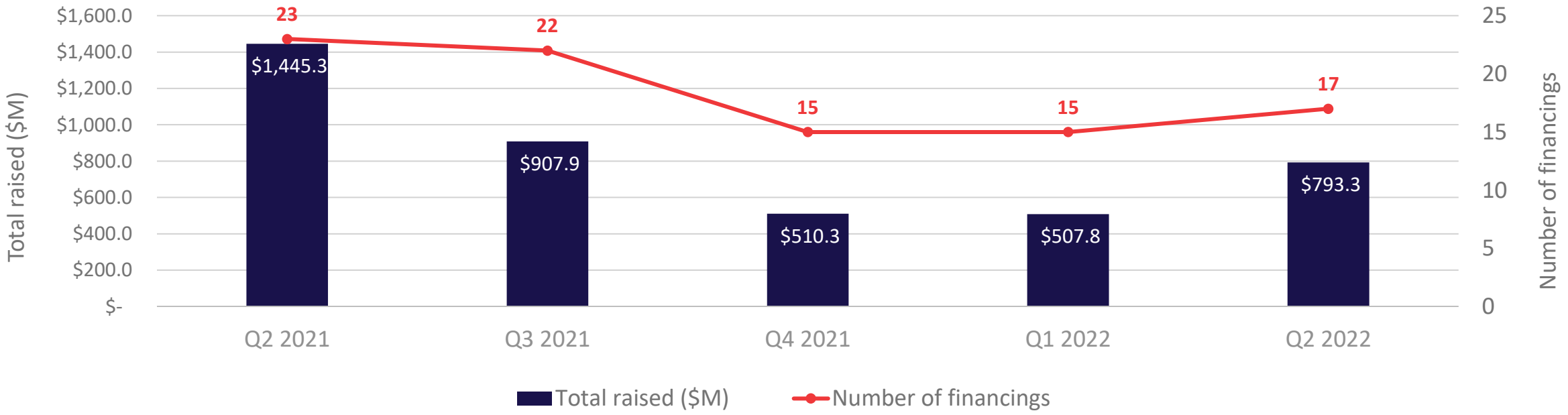
Q2 2022

American Society of Gene + Cell Therapy

Start-up financing for gene, cell, & RNA therapy companies

- 17 start-ups raised an aggregate $793.3 million in seed/Series A financing in Q2 2022, an increase in both volume and value over the previous quarter
- Q2 also featured the first substantial jump in Series A activity after 2 virtually flat quarters
- Almost half of the companies raising seed/Series A rounds in Q2 are in the APAC region, including 3 Chinese firms involved in various RNA technologies

Volume and dollar value of Series A and seed financings for gene, cell, & RNA therapy companies, most recent five quarters



Source: Biomedtracker| Informa, July 2022

American Society of Gene + Cell Therapy

Q2 2022 start-up financing for gene, cell, & RNA therapy companies (1/2)

Deal Date	Deal Title	Modality Type	Company Location	Academic Source	Potential Deal Value (USD, $M)
04/07/2022	Rona Therapeutics Raises $33M Series A Financing	RNA therapeutics	China, Shanghai	Undisclosed	33
04/07/2022	Proof Diagnostics Gets $45M Series A Financing	CRISPR-based molecular diagnostics	United States, Massachusetts, Cambridge	Broad Institute	45
04/13/2022	Cimeio Therapeutics Launches with $50M Series A Round	Gene editing	Switzerland, Basel	University of Basel	50
04/20/2022	Satellite Bio Comes Out of Stealth Mode with $110M in Seed and Series A Financing	Implantable tissue treatments	United States, Massachusetts, Cambridge	MIT; Boston University	110
04/25/2022	Visirna, a new JV Formed with Arrowhead, Launches with $60M Initial Round From Vivo Capital	RNAi therapeutics	China, Shanghai	n/a - JV between Arrowhead Pharmaceuticals and Vivo Capital	60
04/26/2022	Apertura Gene Therapy Launches With $67M in Series A Funding	Gene therapy capsids	United States, New York, New York	Broad Institute	67
04/28/2022	Kelonia Therapeutics Raises $50M Series A Financing	Gene therapy	United States, Massachusetts, Boston	MIT; French National Centre for Scientific Research	50
05/03/2022	Engimmune Therapeutics Raises $16.7M in Seed Financing to Develop Novel T-cell Receptor Therapeutics	Cell therapy	Switzerland, Basel	ETH Zurich	15.8
05/09/2022	BioGenCell Raises $16M in a Seed Round	Cell therapy	Israel, Netanya	Undisclosed	16
05/10/2022	Genascence Raises $10.5M Series A Financing	Gene therapy	United States, California, Palo Alto	Mayo Clinic; University of Florida; NYU Langone Health	10.5

Source: Biomedtracker| Informa, July 2022

Q2 2022 start-up financing for gene, cell, & RNA therapy companies (2/2)

Deal Date	Deal Title	Modality Type	Company Location	Academic Source	Potential Deal Value (USD, $M)
05/17/2022	CellFiber Raises $3M in Series A Round	Cell therapy (mass production technology)	Japan, Tokyo	University of Tokyo	3
05/19/2022	Inceptor Bio Closes $37M Series A Financing	Genetically modified cell therapy (CAR-T, CAR-M, CAR-NK)	United States, North Carolina, Research Triangle	University of North Carolina	37
06/07/2022	Code Biotherapeutics Raises $75M in Upsized and Oversubscribed Series A	Gene and RNAi therapies	United States, Pennsylvania, Hatfield	Undisclosed	75
06/09/2022	Tessa Therapeutics Completes $126M Financing	Genetically modified cell therapy (CAR-T)	Singapore	Baylor College of Medicine	126
06/20/2022	Therorna Raises $42M Series A Financing	circRNA vaccines and therapeutics	China, Beijing	Beijing Advanced Innovation Center for Genomics	42
06/21/2022	Carbon Biosciences Raises $38M in Series A Round	Gene therapy	United States, Massachusetts, Lexington	University of Iowa; University of Massachusetts Chan Medical School	38
06/21/2022	Immuneel Therapeutics Closes $15M Series A Round	Genetically modified cell therapy (CAR-T)	India, Bengaluru, Karnataka	n/a - Founded by Biocon founder/chairperson Kiran Mazumdar-Shaw, Siddhartha Mukherjee, and Kush Parmar	15

Source: Biomedtracker| Informa, July 2022

Notable Q2 2022 start-up gene, cell, & RNA therapy companies

Company details	Academic source	Financing type/amount raised	Lead investor(s)	Therapy areas of interest
Allogeneic CAR-T therapy targeting CD30	Baylor College of Medicine	Series A/$126M	Polaris Partners	Oncology (CD30-positive cancers)
Satellite Adaptive Tissue platform to convert any cell type to bioengineered, allogeneic, and implantable tissue	MIT; Boston University	Seed and Series A combined/$110M	aMoon Growth	Undisclosed
Non-viral 3DNA delivery platform for delivery of gene therapy, RNAi, and other genetic therapies	Undisclosed	Series A/$75M	Northpond Ventures	Duchenne muscular dystrophy; type 1 diabetes

Source: Biomedtracker| Informa, July 2022

Upcoming catalysts

Q2 2022

American Society of Gene + Cell Therapy

Upcoming Catalysts

Below are noteworthy catalysts (forward looking events) expected in Q3 2022

Therapy	Generic Name	Disease	Catalyst	Catalyst Date
Upstaza	eladocagene exuparvovec	Neurology - Other	European Approval Decision	1 Jul 2022 – 31 Jul 2022
Zynteglo	betibeglogene autotemcel	Thalassemia	PDUFA for BLA - First Review	19 Aug 2022 – 19 Aug 2022
Lantidra	Allogeneic Islets of Langerhans	Diabetes Mellitus, Type I	PDUFA for BLA - First Review	19 May 2022 – 31 Aug 2022
Lenti-D	elivaldogene autotemcel	Adrenoleukodystrophy	PDUFA for NDA - First Review	16 Sep 2022 – 16 Sep 2022
Roctavian	valoctocogene roxaparvovec	Hemophilia A	European Approval Decision	1 Jul 2022 – 30 Sep 2022
Yescarta	axicabtagene ciloleucel	Diffuse Large B-Cell Lymphoma (DLBCL) - NHL	Supplemental CHMP Opinion	1 May 2022 – 31 Oct 2022
Oxlumo	lumasiran	Hyperoxaluria	CHMP Supplemental Opinion	1 May 2022 – 31 Oct 2022
EtranaDez	Etranacogene Dezaparvovec	Hemophilia B	CHMP Opinion	1 Sep 2022 – 30 Nov 2022
Amvuttra	vutrisiran	Hereditary Transthyretin (hATTR) Amyloidosis With Polyneuropathy (Familial Amyloid Polyneuropathy)	CHMP Opinion	1 Jun 2022 – 31 Dec 2022
Oxlumo	lumasiran	Hyperoxaluria	Supplemental Approval Europe (PH1)	1 Jul 2022 – 31 Dec 2022
Tab-cel	tabelecleucel	Hematologic Cancer	CHMP Opinion	1 Aug 2022 – 28 Feb 2023
Amvuttra	vutrisiran	Hereditary Transthyretin (hATTR) Amyloidosis With Polyneuropathy (Familial Amyloid Polyneuropathy)	Approval Decision (Europe)	1 Aug 2022 – 28 Feb 2023

Source: Biomedtracker| Informa, July 2022

Appendix

Methodology, sources, & glossary of key terms

Q2 2022

American Society of Gene + Cell Therapy

Methodology: Sources and scope of therapies

Sources for all data come from Informa Pharma Intelligence

Pipeline and trial data

- Data derived from **Citeline (Pharmaprojects and Trialtrove)**
- Therapeutic classes included in report categorizations:
  - Gene therapies: Gene therapy; cellular therapy, chimeric antigen receptor; cellular therapy, T cell receptor; lytic virus
  - Cell therapies: Cellular therapy, other; cellular therapy, stem cell; cellular therapy, tumor-infiltrating lymphocyte
  - RNA therapies: Messenger RNA; oligonucleotide, non-antisense, non-RNAi; RNA interference; antisense therapy

Deal, financing, and catalyst data

- Data derived from **Biomedtracker**
- The following industry categorizations of deals are included: Gene therapy, cell therapy; antisense, oligonucleotides

Glossary of Key Terms

Therapy Type Definitions

Gene therapy is the use of genetic material to treat or prevent disease. For the purpose of this report, the following terms shall mean the following:

Gene therapy	Therapies containing an active ingredient synthesized following vector-mediated introduction of a genetic sequence into target cells *in-* or *ex-vivo*. Used to replace defective or missing genes (as in cystic fibrosis) as well as to introduce broadly acting genetic sequences for the treatment of multifactorial diseases (e.g. cancer). Direct administration of oligonucleotides without using vectors is covered separately in the antisense therapy class; RNA interference class; or oligonucleotide, non-antisense, non-RNAi class. Platform technologies for gene delivery are covered separately in the gene delivery vector class.
Cellular therapy, chimeric antigen receptor **Falls under gene therapy in this report*	Cellular therapy consisting of T cells that have been modified to express a chimeric antigen receptor (CAR) – this is a cell surface receptor that gives the T cells the ability to target a specific protein and fight the targeted cells.
Cellular therapy, T cell receptor **Falls under gene therapy in this report*	Cellular therapies whereby natural T-cells collected for the patient, are engineered to express artificial receptors (usually through viral transfections) that would target specific intracellular antigens (as peptides bound to proteins encoded by the major histocompatibility complex, MHC).
Lytic virus **Falls under gene therapy in this report*	Therapies which have a replication-competent virus, that lyse pathogenic cells directly. These are normally genetically modified to render them harmless to normal tissues. Examples include oncolytic viruses which specifically attack cancer cells.

Glossary of Key Terms

Therapy type definitions, cont.

Cell therapy includes the following therapeutic classes:

Cellular therapy, stem cell	Regenerative therapy which promotes the repair response of injured tissue using stem cells (cells from which all other specialized cells would originate).
Cellular therapy, tumor infiltrating lymphocyte	Adoptive cellular transfer of tumor resident T cells from tumor material, their expansion *ex vivo,* and transfer back into the same patient after a lymphodepleting preparative regimen.
Cellular therapy, other	Cellular therapies that do not fall under the categories of cellular therapy, stem cell; cellular therapy, CAR; cellular therapy, TIL; cellular therapy, TCR; or the specific cellular therapy are unspecified.

Glossary of Key Terms

Therapy type definitions, cont.

RNA therapy includes the following therapeutic classes:

Messenger RNA	Therapies that carry the desired mRNA code to overcome genetic mutations. The mRNA sequence will replace the defective mRNA in a patient and starts producing the desired protein.
Oligonucleotide, non-antisense, non-RNAi	Synthetic therapeutic oligonucleotides which operate by a mechanism other than antisense or RNA interference (RNAi). This includes ribozymes, aptamers, decoys, CpGs, and mismatched and immunostimulant oligonucleotides. Sequences delivered using vectors (gene therapy) are covered separately in “gene therapy.“ Antisense and RNAi oligonucleotides are covered separately in “antisense therapy" and "RNA interference,“ respectively.
RNA interference	Includes products which act therapeutically via an RNA interference (RNAi) mechanism, including small interfering RNAs (siRNAs). These may be synthetic oligonucleotides, or RNAi sequences may be expressed from a vector as a form of gene therapy (see “gene therapy" therapeutic class). *In vivo*, these sequences block the expression of a specific protein by forming an RNA-induced silencing complex, which then specifically binds to and degrades a complementary mRNA encoding the target protein. The use of RNAi purely as a drug discovery tool (e.g., in transgenic animal model production or in target validation) is not covered in this section.
Antisense therapy	Antisense compounds under development as potential therapeutics. These may be synthetic oligonucleotides, or antisense RNA may be expressed from a vector as a form of gene therapy. They may prevent the expression of a specific protein *in vivo* by binding to and inhibiting the action of mRNA, since they have a specific oligonucleotide sequence which is complementary to the DNA or RNA sequence which codes for the protein.

Glossary of Key Terms

Development status definitions

Pipeline	Drugs that are in active development
Preclinical	Not yet tested in humans
Phase I	Early trials, usually in volunteers, safety, PK, PD
Phase II	First efficacy trials in small numbers of patients
Phase III	Large scale trials for registrational data
Pre-registration	Filing for approval made to regulatory authorities
Approved	Approval from relevant regulatory authorities for human use

Unspecified indications

Cancer, unspecified	Indications for which the specific tumor type is not specified
Cancer, hematological, unspecified	Indications for which the specific hematological cancer is not specified
Cancer, solid, unspecified	Indications for which the specific solid tumor is not specified

Deal type categories

Alliances	Co-marketing, co-promotion, disease management, joint venture, manufacturing or supply, marketing-licensing, product or technology swap, product purchase, R+D and marketing-licensing, reverse licensing, trial collaborations
Financing	Convertible debt, FOPO, IPO, nonconvertible debt, financing/other, private investment in public equity, private placement, royalty sale, special-purpose financing vehicle, spin-off
Acquisitions	Buy-out, divestiture, spin-out, full acquisition, partial acquisition, reverse acquisition

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