What's Difference Between Academic and Industrial R&D?

Chasing 3Ps: Publications, Patents, and Products

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Academia & Industry - What Are They?

Academia

- Universities
- National laboratories (e.g., KIST, ETRI in Korea)
- Research hospitals
- Other non-profit research institutes (e.g., HHMI in US)

Industry

- Companies - big corporations (e.g., Samsung, Medtronic)
- Companies - startups
- Consulting firms
- Contracted research organizations (CRO)

Academia & Industry - Characteristics

Academia

- Issuing degrees/diplomas (B.S., M.S., Ph.D., M.D., etc)
- Non-profit (no commercial activities for profit)
- Most activities are tax-funded (but also donation-funded too)
- Senior members (faculties) are often tenured
- No shareholders

Industry

- Not educational institution
- For-profit (commercial activities for profit)
- Most activities are private-funded (but also publicly-funded too)
- Employees are mostly not tenured
- Have shareholders

Academia & Industry - Goals of R&D

Academia

- Education & training of students
- Advancing knowledge of humankind
- Risky and/or long-term research funded by the public
- Public awareness of science & engineering

Industry

- Product development and maturation for commercialization
- Generating scientific evidence for products/services, often for regulatory purposes (FDA premarket submissions, etc)
- Strengthening intellectual property (IP) position of the company for current & future products

Academia & Industry - Similarities & Differences

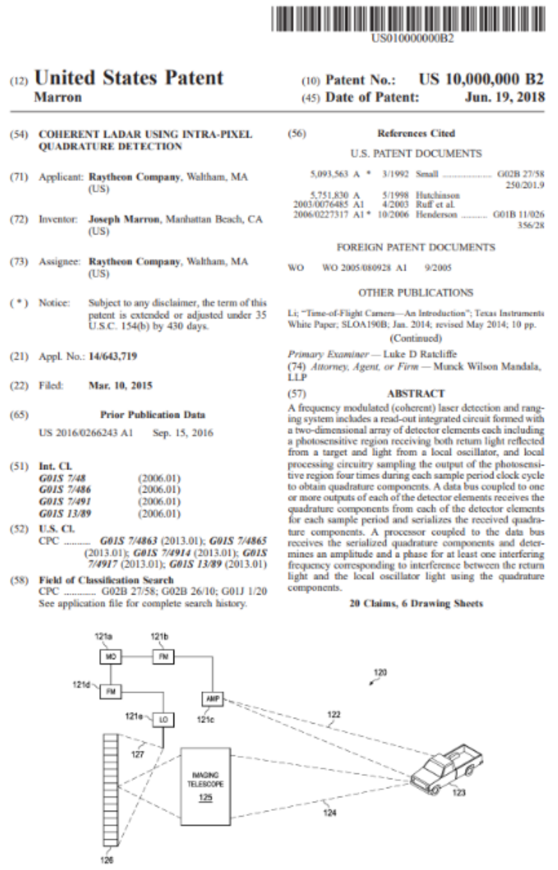
Similarities in R&D

- Science & engineering-driven
- Publish R&D outcomes (papers, conferences, press-release, etc)
- Generating intellectual properties (IP) & patents
- IP & patents are owned by the employer (academic institutions or companies)

Differences in R&D (industry vs. academia)

- Industry R&D requires economic/financial justification
- Industry R&D requires specific timelines and milestones
- Industry R&D is highly reliant on standard tests/methods
- Industry R&D weighs a lot more on patents than papers
- Industry R&D is sensitive to patent infringement

3Ps for R&D: Paper, Patent, and Product



United States Patent
Marron

Patent No.: US 10,000,000 B2
Date of Patent: Jun. 19, 2018

COHERENT LADAR USING INTRA-PIXEL QUADRATURE DETECTION

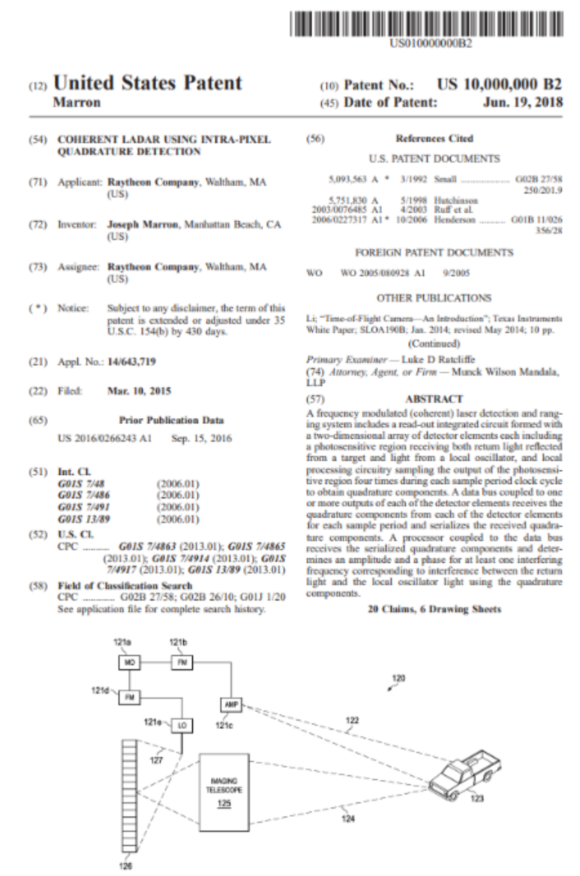
For R&D activities, there can be three key outcomes:

- P1 - Papers
- P2 - Patents
- P3 - Products

Academia and industry typically focus on different outcomes as a result of R&D activities due to their differences in nature and goals:

- **Academia:** Paper > Patent > Product (rarely pursued)
- **Industry:** Product & Patent (equally important) > Paper (rarely pursued)

3Ps for R&D: Are These Mutually Exclusive?



(12) United States Patent
Marron

(10) Patent No.: US 10,000,000 B2
(45) Date of Patent: Jun. 19, 2018

(54) COHERENT LADAR USING INTRA-PIXEL QUADRATURE DETECTION

(71) Applicant: Raytheon Company, Waltham, MA (US)

(72) Inventor: Joseph Marron, Manhattan Beach, CA (US)

(73) Assignee: Raytheon Company, Waltham, MA (US)

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FOREIGN PATENT DOCUMENTS

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OTHER PUBLICATIONS

For individual researchers, these outcomes of R&D are NOT mutually exclusive and often evolve throughout one's career. Hence, it's important to know key features of all three, especially for early-career researchers.

My personal example:

- **During B.S. at KAIST:** Paper publication focused (as an undergraduate researcher in several labs)
- **During M.S. at MIT:** Paper publication focused on purely academic topics
- **During Ph.D. at MIT:** Paper publication on translation topics + Patent generation based on developed technologies from academic projects
- **In industry/startup:** Product development + Patent generation as full-time job & paper publication as personal hobby

Let's cover each one by one in further detail.

Papers - Process of Paper Publication

R&D and publication of the outcome as a paper takes a long list of steps, which is often the backbone of graduate training. A typical process is summarized below (for journal papers):

1. Ideation
2. Literature review (mostly on peer-reviewed articles and papers)
3. Idea development (e.g., feasibility check & basic science investigation)
4. Idea maturation (e.g., protocol/method development & experimental planning)
5. Data collection (typically the most time-consuming part)
6. Analysis of collected data (typically Steps 5 & 6 are iteratively repeated)
7. Manuscript preparation - writing & figures
8. Initial submission to journal editor (this often repeats a few times until being sent out for review)
9. Revision of the manuscript based on reviewers' & editor's comments
10. Acceptance for publication & copy-editing
11. Publication of paper

Planning Phase → Execution Phase → Publication Phase

Papers - Process of Paper Publication

Paper publication can be a tedious and lengthy process with lots of ups and downs. For biomedical areas, it typically takes longer than other fields due to the nature of subject matter.

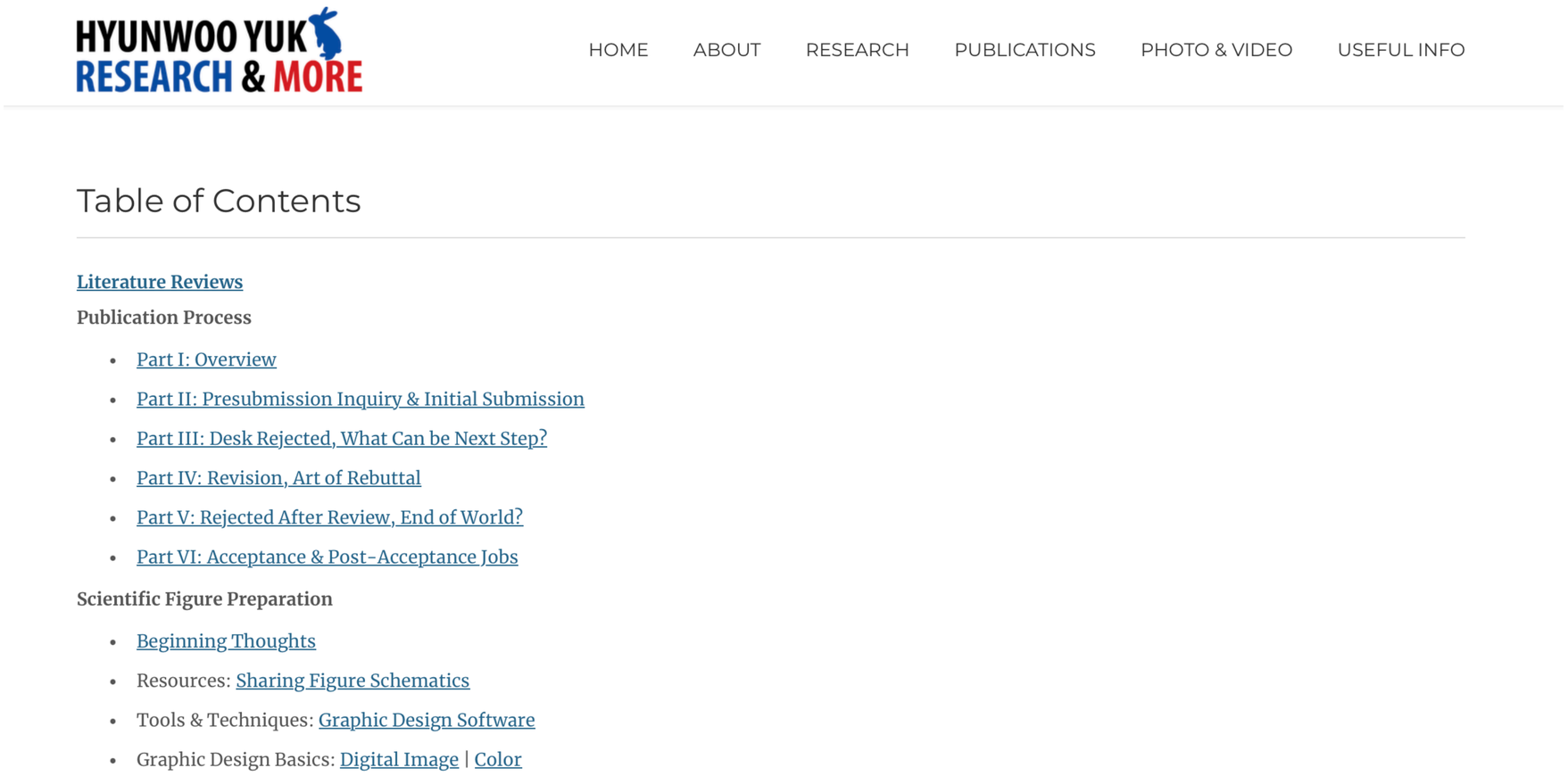
An example from one of my recent paper:
Dry double-sided tape for adhesion of wet tissues and devices, *Nature* **575**, 169-174 (2019)

1. Ideation (Q2 2017)
2. Literature review & idea development (Q4 2017)
3. Data collection & analysis (Q2 2018)
4. Manuscript preparation & initial submission (Q3 2018) → Desk rejection without review
5. Revision & re-submission (Q2 2019) → Sent out for external review (Q2 2019)
6. Reviewer comments (Q2 2019)
7. Major revision & revision submitted (Q3 2019) → Minor revision & revision submitted (Q3 2019)
8. Accepted (Q3 2019)
9. Published online (Q4 2019)

~ 2.5 years from ideation to publication - this is a pretty fast case

Papers - Process of Paper Publication

You can find additional information on my website where you can find detailed introduction & additional resources (including cover letter & figure examples):
https://www.hyunwooyuk.com/table-of-contents.html



Papers - Key Features in Academia & Industry

While both academia and industry R&D can generate papers, there are several distinctive features of paper publication in academia & industry:

nature

Science

AAAS

Academia

- Strong inclination on early-stage R&D (idea & concept) and basic science
- For biomedical areas, typically based on bench top and pre-clinical data
- Strong preference for fancy multi-disciplinary journals (so-called CNS)
- Typically funded by government funding agencies
- Often related to academic career development purposes too

Industry

- Strong inclination on later-stage R&D (real-world validation) and applied science & engineering
- For biomedical areas, typically based on human (clinical) trial data
- Less preference for fancy journals. Often published in specialized journals.
- Typically funded by corporate resources (internally or sponsored research)
- Strongly tied to commercialization

Why Industry Pursues Papers Less than Academia?

There is a significantly higher preference for papers in academia than in industry. Several factors result in the less appetite for papers in industry R&D:

Confidentiality & competition

- Not all IP are published into patents (e.g., trade secrets) & patents cannot 100% protect sometimes
- Due to confidentiality and competition concerns, a large portion of corporate R&D cannot be published to the public.

Mismatch in requirements for commercialization & paper publication

- Paper publications often require things not needed for the commercialization process (reviewers are mostly academics).
- Commercialization is a priority for industry, so if misalignment is too big, it cannot be justified.

Relative cost of R&D

- R&D is substantially more expensive in industry than in academia.
- Early-stage exploratory R&D (most papers) is a lot more limited in industry setup than in academia.

Patents - Process of Patent Issuance

Patents and papers have similar processes in early-stage (before filing - hence often done in parallel) but significantly different afterward. Simplified process summary:

1. Ideation/conceptualization
2. Prior art review (mostly on patents)
3. Idea/concept development (e.g., feasibility check & claim exploration)
4. Reduction to practice (example embodiments)
5. Patent application preparation & finalization of claims
6. Filing of patent (including PCT application if international patents will potentially be pursued)
7. Receiving office actions & responses (often claims are adjusted during this process)
8. Patent allowed/granted
9. Patent issuance

Planning Phase → Execution Phase → Patenting Phase

Overlaps with paper publication

Patents - Process of Patent Issuance

Patent issuance can take a while depending on cases and examiners.

An example from one of my recent patent:
US 2021/0163797

1. Ideation (Q3 2018)
2. Prior art review (Q4 2018)
3. Idea/concept development (Q1 2019)
4. Reduction to practice (Q3 2019)
5. Tech disclosure submitted to MIT Technology Licensing Office (Q3 2019)
6. Provisional patent preparation & filing (Q4 2019, PCT application filed together) - *priority date*
7. Non-provisional patent application filing (Q4 2020)
8. Publication of provisional application (Q2 2021)
9. Office action received (Q2 2023) → Response submitted (Q3 2023)
10. Notice of allowance & patent issuance (Q4 2023)

~ 4 years from filing to patent issuance - this is a bit longer but not unusually long

Patents - Some Key Timeline for Patents

There are important timelines to know for patents, especially for academic researchers who might be not very familiar with the patent process:

Provisional & Non-provisional (utility) patents in the US

- In the US, the provisional patent has **12-month** pendency within which a non-provisional (utility) patent should be filed to keep the priority date.

PCT deadline for entering the national phase

- For international protection, PCT application is often filed together with a domestic application.
- PCT application should be filed within **12-month** from the priority date.
- National phase should be entered within **30- or 31-month** from the priority date for each desired country. This is particularly important if the assignee does not file international patents without additional sponsorship or licensing agreements (very common for universities).

Most importantly, patents should be filed before any public disclosure (paper publications, conference proceedings, or even presentations at public events).

Patents - Key Differences in Papers vs. Patents

Both papers and patents are published results from R&D. But, they are different in key aspects:

	Papers	Patents
Decision Maker	Journal Editors	Patent Officer (USPTO in US)
Legally-Defined/Binding?	No	Yes
Protect Exclusivity?	No	Yes
Give Commercial Right?	No	Yes
Preparer	Authors/Inventors	Patent Attorney
Cost	Low	High
Maintenance Fee	No	Yes
Expire?	No	Yes (20 years from filing in US)
Specific to Each Country?	No	Yes
Ownership	Copyright to publisher (& authors)	Assignee

Why Patents Are More Critical than Papers in Industry?

Patents are significantly more valuable in the industry than papers for several reasons:

Freedom of operation in commercial activities

- Having patents for products/services is critical to giving 'freedom of operation' to the company.
- Without freedom of operation, commercialization is difficult due to the risks of patent infringements and lawsuits.

Legal protection against competitors

- Patents give exclusive rights during the active period (20 years since filing), preventing competitors from copying your technology in their products.
- If someone infringes your patents, the infringer can be sued to stop infringement & recover financial damages (if wins the lawsuit).

Economic/financial values

- Patents are a core part of commercial deals (merger, acquisition, licensing, etc) that can generate significant economic/financial gains.

Then, Paper Is Not Worthy to Pursue?

However, this does not mean that papers are not meaningful to pursue. Papers have unique advantages over patents in R&D for both academia and industry:

Scientific credibility

- Peer-review process by experts in the field of paper publication provides higher scientific credibility.
- Especially for prestigious journals, the reputation of such journals helps the credibility of the work and technology published there.

Broader accessibility

- Due to format and readership, papers can have a lot broader accessibility to both professional and general public audiences.
- Nowadays, journals typically do extensive outreach programs in social networks, helping broader dissemination of the work/technology than patents or industry-led press releases.

Products - R&D for Real-World Impacts

Products are real-world incarnations of R&D either in the form of physical products or services. Products require diverse types of R&D for different purposes:

Product development

- R&D for standard testing & quality control (specification, etc)
- R&D for (scalable) manufacturing & process
- R&D for packaging & applicators

Regulatory compliance

- cGMP manufacturing
- GLP biocompatibility data generation
- GLP efficacy data generation
- Sterilization validation
- Shelf-life validation
- Packaging validation

Products - R&D for Real-World Impacts

Products are real-world incarnations of R&D either in the form of physical products or services. Products require diverse types of R&D for different purposes:

Examples of R&D for products from my team:

- Protocol development & testing for biocompatibility (ISO, USP)
- Protocol development & testing for mechanical properties (ASTM)
- Manufacturing & process development
- Packaging & applicator development
- Pre-clinical model development & validation
- Product specification development & validation (USP)
- Instruction for use (IFU) development & validation
- User & design failure mode and effects analysis (U/DFMEA)
- Sterilization method development & validation (ISO, USP)

Not generating papers or patents but core R&D activities for commercialization and regulatory clearance

Product R&D - It Can be Less Fancy But Important

Product R&D is day-to-day work in the industry, probably the largest portion of R&D activities. Since product R&D can be more task-specific routine work without generating either papers or patents, it can be less fancy - but it is critically important.

Bridging the gap between idea & reality

- Often ideas in papers & patents are premature to be used in actual applications.
- Productization by R&D is essential to bridge this gap.

Making real-world impacts

- Unlike papers & patents, products are real-world entities with actual users.
- It's actual form that can make real-world impacts not fancy wishful writings & figures.

3Ps for R&D - Some Personal Lessons Learned

Lessons learned for papers

- Fancy journal papers are good things to have if you can. But, its true value is often very exaggerated in academia.
- Paper publication, especially in collaborative projects, is a very good way to learn new things.
- Be cautious about taking feedback from academic peers in terms of real-world applicability.

Lessons learned for patents

- Should know key timelines and aspects of patent filing and process sooner rather than later.
- If patents were mishandled, commercialization opportunities could go nowhere despite the technology is great & science is solid.
- Remember that your employer will own patents from your invention. Be smart about it.

Lessons learned for products

- Industry R&D and experts for product development & validations are way more professional than academia with much higher standards.
- Product R&D is a lot harder than paper publication. It requires teamwork in a bigger scale.

Diverse Careers for Researchers in R&D

Academic careers

- Faculties in universities
- Faculties in research hospitals
- Group leaders/staff scientists in research institutes

Industry careers

- R&D scientist/engineer
- Technology scouting/evaluation leads
- Consultants

Other careers

- Startup founders
- Corporate managers (after getting a MBA from business school)
- Patent attorney (after getting a JD from law school)
- Investors (especially in tough/deep tech VCs)

Questions?