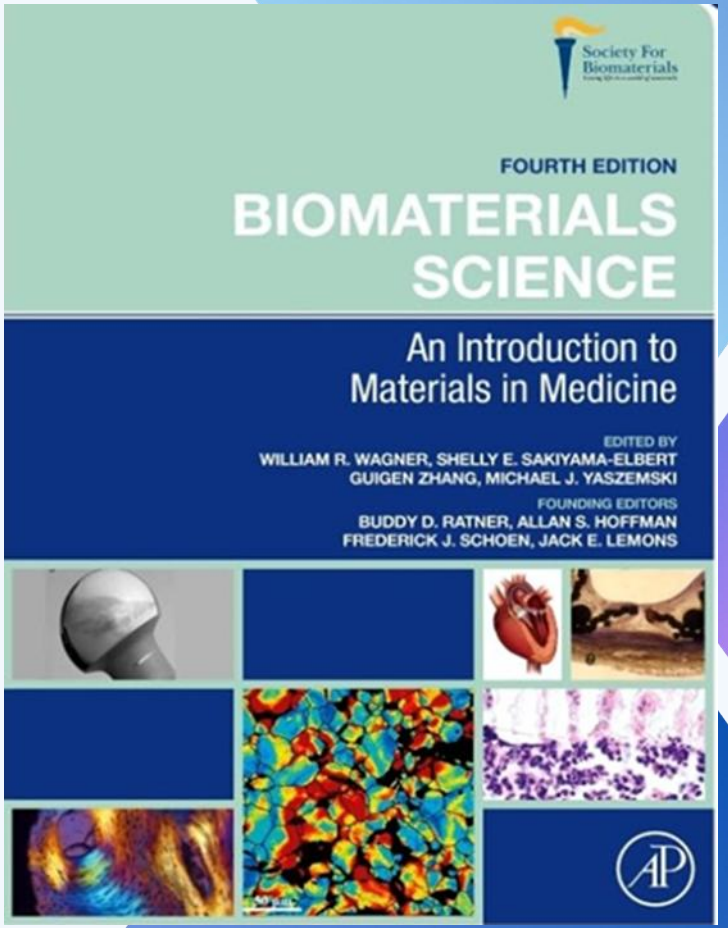
# Legal and Ethical Frameworks for Biomaterials and Medical Product Development

An integrated review of legal concepts and moral issues for engineers and scientists in the medical device industry.



# Part 1: Legal Concepts for Biomaterials Engineers

Navigating the Legal Landscape of the Medical Device Industry

# Introduction: Bridging Engineering and Law

The intricacies of the law are often as unfamiliar to biomaterials engineers as the intricacies of engineering are to lawyers. This creates a knowledge gap that must be addressed.

Throughout their careers, biomedical engineers and other medical device professionals will inevitably encounter issues with legal ramifications.

# The Importance of Legal Awareness

Developing a general awareness and familiarity with common legal situations is not just advisable; it is a professional necessity.

This awareness enables professionals to identify potential legal issues, even if they are not equipped to handle them alone. The key is knowing when to martial the appropriate legal resources for assistance.

# Supporting the Organizational Mission

Properly managing legal issues does more than just mitigate risk.

It can actively support and even reinforce the mission of the individual and their employer or organization.

# Key Areas of Legal Concern

Medical device professionals can expect to routinely encounter legal issues across several general categories. Understanding these categories provides a foundational map of the legal landscape.

- Employment agreements
- Confidentiality and biomaterials use agreements
- Intellectual property: Biomaterial Patents, trade secrets, and freedom to operate
- Contract negotiation, performance, and compliance of biomaterials
- Sponsored research agreements biomaterial R&D
- License agreements for biomaterials

# The Overlap of Legal Concepts

Fortunately, from an engineer's perspective, the legal issues associated with these six key areas partially overlap. This interconnectedness simplifies the learning process.

Becoming acquainted with the legal principles in one category will assist in understanding and anticipating issues in the others.

# Industry vs. Academic Perspectives

While professionals in industry and academia may approach legal issues from different perspectives, a fundamental awareness remains valuable for both.

The importance of various influencing factors may differ, but the core legal issues tend to recur. This chapter focuses on the industry perspective, which is also informative for academics who interact with companies.

# Employment Agreements: The First Encounter

Perhaps the first legal document a medical device professional encounters post-university is the employment agreement.

While the focus is often on compensation and benefits, the legal clauses carry long-term weight.

# The Offer Letter: Initial Terms

Typically, an offer letter will cover primary topics such as job title, compensation, benefits, vacation time, and opportunities for advancement.

However, it may also include a critical legal provision: the "employee at will" clause.

# Understanding "Employee at Will"

The "employee at will" provision means the employer reserves the right to terminate employment at any time, with or without cause.

It is highly unlikely that an established employer will allow a new employee to negotiate this provision away. This limits the employee's recourse in the event of what they might perceive as an unwarranted termination.

# The Formal Legal Contract

Beyond the offer letter, a formal legal contract will address deeper obligations. These provisions can have significant consequences for future job opportunities and persist for years after employment ends.

- Treatment of confidential information
- Assignment of inventions
- Protection of trade secrets
- Non-competition
- Non-solicitation

# Employment Agreement: Confidentiality

## Personal Obligation to Protect Secrecy

The confidentiality provision establishes that the employee is personally bound to protect the secrecy of any confidential information they are exposed to during employment.

This includes information belonging to the employer and any third parties.

# Confidentiality: A Two-Way Street

A less prominent, but equally important, clause states that the new employee may not bring, use, or rely on any unauthorized confidential information from a prior employer.

The ubiquity of these provisions highlights that companies take the protection of confidential information very seriously. It belongs to the company, not the individual.

# Consequences of a Confidentiality Breach

Any failure to respect agreed-upon confidentiality terms, whether intentional or accidental, can have severe consequences for the employee.

This can include immediate termination and significant damage to their professional reputation.

# Employment Agreement: Assignment of Inventions

## Ownership of Intellectual Property

These provisions establish a critical principle: the employer, not the employee, is the owner of any inventions created by the employee in the course of their work for the company.

# Assignment of Inventions: The Obligation to Cooperate

The assignment of inventions provision imposes a legal obligation on the biomaterials engineer to cooperate with the company in the patent prosecution process.

This includes executing any necessary documents related to patent applications as reasonably requested.

# Employment Agreement: Protecting Trade Secrets

Protecting trade secrets is one of the most important confidentiality obligations an employee has. The seriousness of this is underscored by federal law.

## The Defend Trade Secrets Act of 2016 (DTSA)

This act established the right for a trade secret owner to sue in federal court for unauthorized disclosure or use of trade secrets by current or former employees.

# DTSA: Potential Consequences

The DTSA allows companies to seek punitive damages and reimbursement of attorney's fees against former employees. Judgments can range from several thousand to millions of dollars.

The importance of protecting trade secrets, whether by employment agreement, state law, or the DTSA, cannot be overemphasized.

# Employment Agreement: Non-Competition

Non-competition provisions present perhaps the most obvious and direct restrictions on a professional's future employment opportunities.

## Typical Restrictions

Such provisions typically prevent a departing employee from working for or consulting for any competitor of the former employer for a post-employment period of approximately 1 to 2 years.

# Non-Competition: Strategic Career Considerations

When evaluating employment opportunities, it is crucial to consider how non-competition restrictions might impact future career advancement.

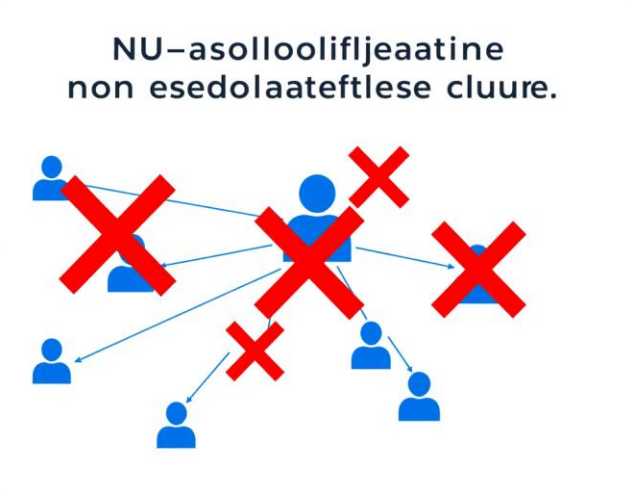
Medical device professionals should aim to diversify their skill sets so that finding a new job will not place them in breach of their non-competition obligations.

# Employment Agreement: Non-Solicitation

Non-solicitation provisions are similar to, but distinct from, non-competition provisions. They focus on relationships rather than direct employment.

- Prevents former employees from enticing away colleagues.
- Places restrictions on entering business arrangements with former customers or contractors.
- Typically lasts for 1 to 2 years post-employment.

# Non-Solicitation: Impact on Professional Networks




Biomaterials engineers should be aware of how non-solicitation provisions can impact the range and types of professional and business relationships they might engage in after leaving an employer.

# Confidentiality & Materials Use Agreements

## The Ubiquitous Non-Disclosure Agreement (NDA)

Perhaps the most frequent legal document an engineer will encounter is the confidentiality agreement, also known as a Non-Disclosure Agreement or NDA.

Most organizations have protocols requiring an NDA before any confidential information is shared with a third party.

# The Purpose of an NDA

NDAs are used when it is desirable or necessary to share confidential information so that a potential collaboration or contractual agreement can be fully considered.

Consequently, an NDA is often signed before any substantive discussions occur. If a formal relationship develops, the NDA's confidentiality terms will persist and may even be enhanced.

# Defining "Confidential Information"

Each NDA is focused on one of an organization's most valuable assets: its confidential information. However, there is no single standard definition.

Therefore, one of the first things any reader encounters in an NDA is a detailed definition of what constitutes "Confidential Information" for the purposes of that specific agreement.

# Example Definition: A Lawyer's Language

A typical provision in a mutual NDA might state: "Confidential Information shall mean any and all technical business and other information including, without limitation, patent, copyright, trade secret and proprietary information, techniques, sketches, drawings, models, inventions, know-how, processes, formulae, apparatus, equipment and biological materials..."

The Ubiquitous Non-Disclosure Agreement (NDA)

# The Engineer's Critical Review

The lawyer drafting such expansive language is almost certainly not a biomaterials engineer. The lawyer will never understand the business and technical concerns as well as the engineer.

It is therefore possible that the standard legal definition might miss the specific category of information you anticipate sharing. Definitions in contracts are critical.

# Actionable Advice for Engineers

Medical device professionals must pay particular attention to these definitions. If you believe something important is missing from the definition of "Confidential Information," this issue should be raised and pursued until it is addressed to your satisfaction.

# Maximizing NDA Protection: Three Key Steps

To minimize the risk of confidential information being misused by a third party, at a minimum, the following steps should be taken:

Step 1: **Execute Before Sharing**

Ensure a fully executed NDA is in place with the receiving party before any confidential information is shared.

Step 2: **Mark Information Clearly**

Ensure any confidential information provided is clearly marked as belonging to your organization.

Step 3: **Manage Verbal Disclosures**

Carefully consider how information disclosed verbally will be treated as confidential under the terms of the NDA.

# Step 1: Review the Executed NDA

Before sharing information, the medical device professional should request and review an executed copy of the NDA to understand:

- The defined scope of confidential information.
- The time period the receiving party is obligated to protect the information (often 1-5 years).
- The limitations on how the confidential information may be used.

# Mutual vs. One-Way NDAs

It is crucial to ensure the NDA has been written to protect your organization's information, not just the other party's.

**Mutual NDA**

Protects confidential information shared by both parties.

**One-Way NDA**

Protects only one designated party's information. This is often preferable if it is your organization's information being protected.

# Step 2: The Importance of Marking

NDAs often require the disclosing party to clearly mark all shared information as confidential. It is the responsibility of the professional sharing the information to do this.

Simply marking a document "Confidential" may not be sufficient, as it doesn't establish ownership.

# Best Practices for Marking Documents

The simplest remedy is to include the organization's name in the label that identifies a document as confidential (e.g., "[Company Name] Confidential").

This label should be inserted as a header or footer on every page of the confidential document. This is a prudent practice for all sensitive internal documents as well.

# Step 3: Handling Verbal Disclosures

Many NDAs state that information conveyed verbally will not be treated as confidential unless it is identified as confidential at the time of discussion.

This creates a significant risk if not managed properly.

# The Follow-Up Requirement for Verbal Disclosures

The NDA may also require the disclosing party to send a written summary to the receiving party within a defined period (e.g., 30 days), specifically describing the confidential information that was shared verbally.

This is a burdensome process, so a disciplined approach is to have an advance plan for how verbal disclosures will be documented and protected.

# Information Excluded from NDA Protection

NDAs invariably include limitations on the categories of information that may be protected. Common exclusions include:

- Information the receiving party already possessed.
- Information that has entered the public domain through no fault of the receiving party.
- Information that the receiving party independently develops, without reference to the disclosing party's information.

# The Challenge of Proving Independent Development

Proving that information was independently developed can be fraught with uncertainty. It should not be relied upon without careful planning, procedures, and legal guidance.

Diligent record-keeping in a laboratory notebook can be essential for demonstrating independent development.

# Materials Use Agreements (MUAs)

When sharing sample materials that incorporate confidential information, it is common to execute a Materials Use Agreement (MUA) or Materials Transfer Agreement (MTA) in addition to an NDA.

An MUA extends limitations on use, similar to those in an NDA, to any proprietary materials shared with the receiving party.

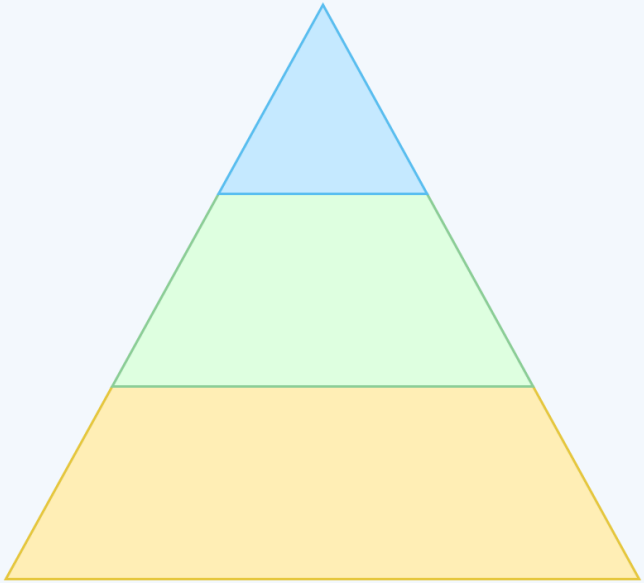
# Proprietary vs. Confidential

In the context of intellectual property law, the term "proprietary" refers to materials based on technology that a party may own, even if the technology itself is not confidential.

For example, patents are public documents describing materials that are proprietary to the patent owner, but they are not confidential.

# Key MUA Issues for Engineers

A medical device professional considering an MUA should be particularly concerned with three issues:



1. How the material can be used.

2. Obligation to report results.

3. Ownership of resulting inventions.

# MUA Issue 1: Defining the Purpose of Use

Proprietary materials are valuable. When sharing them, a limited and specific purpose for which the material can be used by the third party must be clearly defined.

This ensures the receiving party does not have unlimited rights to do whatever they want with the material. This is especially important if the third party has unique capabilities that could enhance the material's value.

# MUA Issue 2: The Right to See Results

If an MUA defines a clear purpose, it's reasonable to expect the receiving party to produce results. The sharing party's right to review these results should be clearly defined.

The MUA should include a specific provision requiring the production of a detailed written report. This information is essential for making informed decisions about future investment.

# MUA Issue 3: Ownership of New Inventions

Before sharing materials, an engineer must consider whether the third party's activity could result in a new, patentable invention. If so, proceed with great caution and inform senior management.

# The Risk of Ceding Patent Rights

Sharing proprietary material does not automatically make the sharing party an inventor of work conducted by the receiving party.

A serious risk arises that the receiving party may gain patent rights involving or incorporating the sharing party's material, which could be separate and distinct from any rights of the sharing party.

# Mitigating Invention Risk in MUAs

One of the best methods to avoid this risk is to ensure the defined purpose in the MUA is unlikely to result in a new invention.

Clearly define this purpose and the associated methodologies in the MUA. Failure by the receiving party to follow these would constitute a contractual breach, entitling the sharing party to legal remedies.

# Intellectual Property (IP): An Overview


Intellectual property (IP) refers to creations of the mind, such as inventions, trade secrets, trademarks, and designs.

For medical device professionals, the two most important forms of IP that regularly impact their activities are patents and trade secrets.

# Patents vs. Trade Secrets: Two Sides of a Coin

**Patents**

- Publicly accessible document.
- Granted for novel, non-obvious inventions.
- Provides exclusive rights for 20 years.
- A legal monopoly on the use of an invention.

**Trade Secrets**

- Kept confidential.
- Often involves processes or methodologies.
- No expiration date, but rights are lost if it becomes public.
- Protection depends on maintaining secrecy.

# Best Practice: The Inventor's Notebook

To identify and support patent or trade secret rights, biomaterials engineers should always keep an accurate and detailed laboratory notebook, sometimes called an inventor's notebook.

**Key Elements:**

- Dated pages for all work/experiments.
- Signed by the person who wrote the notes.
- Contemporaneously witnessed by the signature of a second person.

# Utility of the Inventor's Notebook

The information recorded in an inventor's laboratory notebook can be extremely helpful for drafting a patent application and is critical for determining inventorship.

Similarly, this information can be dispositive if an organization needs to demonstrate its entitlement to trade secret protection for proprietary methodologies.

# Best Practice: The Invention Disclosure Document

When an engineer believes they have ***created an invention, the next best practice is to prepare an invention disclosure document.***

Many organizations have a preferred template.

# Contents of an Invention Disclosure

- A summary description of the invention.
- The name(s) of the inventor(s).
- The date the inventors believe they completed the invention.
- A detailed discussion of the steps and work performed.
- An explanation of why the creation is different from existing "prior art".

# Engaging an IP Attorney

The most efficient way to engage an IP attorney is to provide them with a detailed, carefully written invention disclosure.

Inventors must educate their IP attorney on the specifics of the invention.

There is a direct correlation between the attorney's understanding and their ability to recommend optimal protection strategies.

# Key Questions for the IP Attorney

A well-written invention disclosure should allow an experienced IP attorney to advise the organization on at least two critical issues:

- The likelihood that the described invention is patentable.
- The likelihood that practicing the invention might infringe on existing third-party patent rights.

# The America Invents Act (AIA) and Urgency

The America Invents Act (AIA) of 2011 established a "first-to-file" system. This means ownership of an invention is determined by the first party to file a patent application, regardless of who created it first.

Filing quickly can make the difference between being able to complete research or having to abandon it.

# The Provisional Patent Application

To optimize the likelihood of being the first to file, patent seekers often file a provisional patent application.

This filing establishes the invention's "priority date." The applicant then has 12 months to enhance the application and convert it to a non-provisional application for examination.

# The Freedom to Operate (FTO) Analysis

An FTO analysis involves researching patents, applications, and other public documents related to prior art that may be similar to the new invention.

Upon completion, the IP attorney can offer informed opinions on patentability and infringement risk.

# Outcomes of an FTO Analysis

The attorney may recommend ways to refine the invention to enhance patentability or reduce infringement risk.

If infringement risk is high and unavoidable, the organization may decide to abandon the project, thereby avoiding potentially crippling litigation costs.

# The Decision: Patent or Trade Secret?

If the FTO is clear, the next decision is whether to patent the invention or maintain it as a trade secret.

A primary factor is that a patent application requires a detailed public disclosure of the invention, sufficient for a "person skilled in the art" to replicate it.

# The Risk of Public Disclosure

Patent applications are typically published 18 months after filing, regardless of whether a patent is ultimately granted.

This means there is a reasonable likelihood that a detailed description of your invention will be published before you know if it's even patentable, effectively giving it away for free if the patent is denied.

# Patent Application Components: Specification

The specification is a detailed description of all aspects of the claimed invention. It must be sufficiently detailed for replication and must include the best way the inventors know to practice it.

In essence, the specification is a complete public disclosure of the invention.

# Patent Application Components: Claims

The claims section is much shorter and precisely describes the features of the invention that are novel, non-obvious, and therefore entitled to 20 years of protection.

The exclusive rights of a granted patent are based specifically on the claims, which must be fully supported by the specification.

# The Inventor's Role in Patent Prosecution

The pursuit of a patent grant, known as patent prosecution, requires continued, focused engagement from the inventors in coordination with their IP attorney.

Inventors have insights the attorney will not possess. Their active participation is crucial for a strong application and successful outcome.

# Final Decision Factors: Patent vs. Trade Secret

The decision often comes down to weighing the value of 20-year exclusivity (patent) against potentially longer but weaker rights (trade secret).

The decision is also financial, as patent prosecution and maintenance can be expensive. An experienced IP attorney can help advise on the relative benefits.

# Contract Negotiation, Performance, and Compliance

When two or more organizations invest jointly in a project, the standard protocol is to execute a written contract.

This document establishes the rights and obligations of each party.

# The Importance of Clarity in Contracts

Contracts can be highly detailed and are drafted with precision. Careful drafting is critical because any lack of clarity can result in misunderstandings about contractual rights and obligations.

Such misunderstandings can undermine cooperation, goodwill, and even lead to breach of contract litigation.

# The Engineer's Responsibility in Contract Review

Biomaterials engineers must be attentive to reviewing and understanding contracts. The various functions they are responsible for will be subject to specific obligations established in the contract.

Failing to carefully focus on provisions related to their responsibilities is a significant professional risk.

# Navigating the Contract: Two General Categories

The provisions of any contract can be divided into two general categories:

Business Terms

The scope of work, deliverables, and associated payment schedule.

Legal Terms ("Legalese")

Clauses that define the legal relationship and procedures for disputes.

# The Engineer's Role in Business Terms

***The biomaterials engineer should play a leading role in defining the business terms, especially the scope of work.***

These terms should be written in plain English. The engineer must ensure they understand these terms and can deliver on them before the organization signs the contract.

# Navigating "Legalese": Category 1

## Disputes and Litigation

This first category of legalese involves issues typically decided by attorneys. While engineers may not be blamed if these terms are suboptimal, they should not be passive.

Engineers should not be reluctant to ask their attorney to clarify the intent, alternatives, and advantages of these provisions.

# Navigating "Legalese": Category 2

## Defining the Business Relationship

This second category should be more easily understandable. It covers topics like ownership of work, project management, termination clauses, confidentiality, and non-competition.

Engineers should work with their attorney to evaluate where standard provisions may be inappropriate and customized terms are needed.

# Post-Execution: The Contract as a Living Document

Once a contract is signed, it should not be put in a drawer and forgotten. The biomaterials engineer must remain familiar with the scope of work.

It is valuable to refer back to the contract periodically to ensure both parties are meeting their obligations in a satisfactory and timely manner.

# Sponsored Research Agreements (SRAs)

SRAs are a key category of contracts where medical device professionals are often the most prominent advocates and leaders.

An SRA typically involves a university agreeing to conduct a clearly defined research project for an industrial entity in exchange for a fixed cost.

# The Engineer's Leading Role in SRAs

Biomaterials engineers can expect to engage proactively in the negotiation of SRA business terms. Their scientific and engineering expertise is indispensable.

The attorney's effectiveness in drafting and negotiation is directly impacted by how effectively the engineer participates in the process.

# SRA Business Terms: Scope of Work

One key component of the business terms is the specific tasks or experiments the university agrees to perform. This is often accompanied by a schedule of deliverables, such as written reports.

This component is often written by the biomaterials engineer in coordination with their university counterpart and attached to the SRA.

# SRA Business Terms: Financials and Personnel

Other important business terms include payment terms and the identity of the principal investigator (PI).

The finance department and company attorney will provide input on payment structures (e.g., upfront, milestone-based, final payments).

# The Principal Investigator (PI) Clause

The SRA should address what happens if the named PI becomes unavailable. Universities often propose they can unilaterally name a replacement or terminate the project.

This can have adverse consequences for the company, as money paid is often nonrefundable and project timelines can be severely disrupted.

# Negotiating the PI Clause

Given the serious consequences, the industry engineer should coordinate closely with their attorney on these terms.

At a minimum, the company may want to ensure the SRA obligates the university to exert best efforts to find a reasonably acceptable replacement and gives the company the right to approve that replacement.

# Intellectual Property Rights in SRAs

Company executives might expect to own all IP resulting from a funded project, but universities generally will not agree to this.

Central to the university's mission is the advancement and open sharing of knowledge. Therefore, universities typically claim ownership of inventions and the right to file patents.

# SRA Strategy: In-House vs. Outsource

If an SRA project could result in a patentable invention, key company decision-makers should collectively consider whether the research should be conducted in-house to ensure exclusive ownership.

If the decision is to proceed with the SRA, careful attention must be paid to the terms describing the company's rights to any resulting invention.

# Securing Rights to SRA Inventions

At a minimum, the SRA should provide the sponsoring company with a first right to negotiate an exclusive license for any patentable invention resulting from the research.

The engineer and attorney should review this provision to ensure it affords the company the necessary opportunity to develop and commercialize the invention.

# SRA Publication Rights

Universities typically reserve the right to publish research results, whether favorable or unfavorable.

If publication of unfavorable results could be damaging, this risk must be considered before signing. The company may wish to conduct potentially damaging components of the research in-house.

# Publication and Patent Implications

Publication of research, even positive results, has implications for patent rights. Public disclosures (e.g., at a conference or in a journal) can forfeit patentability.

The U.S. has a one-year grace period for disclosures by inventors, but many non-U.S. jurisdictions do not. International patent opportunities can be lost instantly upon public disclosure.

# Managing SRA Disclosures

A key responsibility of the engineer managing an SRA is to ensure no research results are inadvertently made public before patent decisions are made and applications are filed.

Ideally, the company should have already decided whether to support patent prosecution and have a term sheet or license agreement in place with the university.

# License Agreements: The Role of Tech Transfer Offices

University technology transfer offices (TTOs) are typically responsible for managing and licensing technologies invented by university researchers.

TTOs are often organized as independent corporate entities, wholly owned by the university, but operating much more like a business than an academic department.

# Negotiating a License Agreement vs. an SRA

The negotiation dynamic for a license agreement is different from an SRA. The Principal Investigator (PI) plays a much less significant role.

Negotiations are managed by an IP specialist within the TTO, who acts independently. Sponsoring companies must build a new relationship with this distinct entity.

# The Engineer's Role in License Negotiation

While a company's attorney or patent license specialist often takes the lead in negotiations, the lead biomaterials engineer for the research plays an integral and indispensable role.

Their technical insight is crucial for evaluating the terms and commitments.

# The Two-Step Licensing Process

Step 1: The Non-Binding Term Sheet

This document summarizes the key business terms of the proposed patent license. It requires input not just from legal and engineering, but also from finance, regulatory, and business line executives.

Step 2: The Binding License Agreement

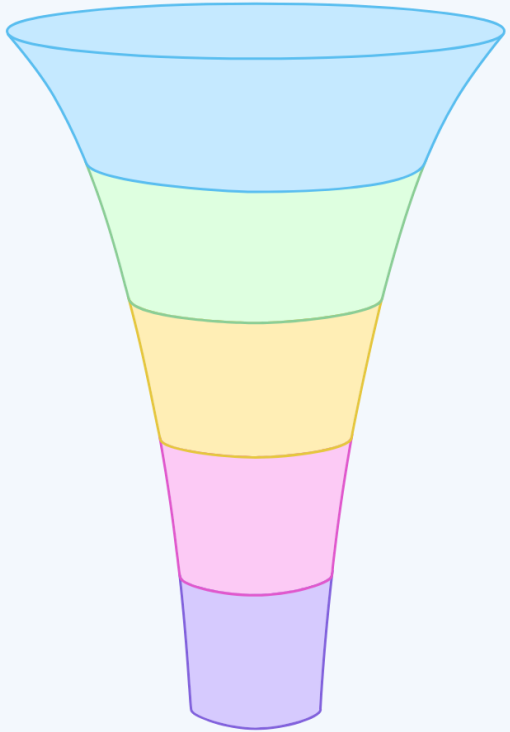
The provisions of the agreed-upon term sheet are incorporated into a comprehensive and legally binding contract.

# License Agreement Milestones

A patent does not equal a commercial product. The technology must still undergo development and regulatory approval.

License agreements typically include a series of development steps, or milestones, that the licensee must achieve to keep the license.

# Example Commercialization Milestones



Completion of a preclinical research project

Commencement of a clinical trial

Completion of that clinical trial

Regulatory approval (e.g., by FDA)

First commercial sale

Failure to achieve these milestones by the agreed-upon schedule may give the university the right to terminate the license.

# Financial Terms of a License Agreement

In addition to the costs of performing milestones, the term sheet will specify payments to the university:

1. **Milestone Payments**

   Payments made as each contractually specified milestone is reached.

2. **License Fee**

   An initial and/or minimum annual fee to keep the license active.

3. **Royalty Fee**

   Typically calculated as a percentage of net revenues from sales of products based on the licensed technology.

# Litigation: An Unfortunate Reality

In a litigious society, it is not surprising for a professional to face the threat or reality of a lawsuit during their career.

Litigation can concern any of the topics discussed, from contract disputes and confidentiality breaches to IP infringement and product liability.

# The Litigation Process

Litigation typically begins with a formal complaint, which may be preceded by a demand letter. Receiving a complaint can be unsettling and immediately places the recipient in a stressful situation.

Companies and universities typically hire outside lawyers who specialize in litigation to represent them.

# The Role of the Litigator

A qualified litigator can provide perspective on risks, detail a range of strategies, and outline possible outcomes.

While no experienced litigator will guarantee a specific result, they should be able to present options that allow the client to make informed choices.

# The Engineer's Role in Litigation

Hiring a litigator does not absolve the engineer from involvement. Litigation is fact-specific.

If the lawsuit concerns activities the engineer was involved in, they will need to spend significant time engaging with the litigation team to ensure the lawyers understand all relevant facts.

# Personal Liability in Litigation

Most lawsuits will not place the medical device professional at risk for personal liability, particularly if they were acting within the scope of their employment authority and did not engage in negligent or malicious conduct.

Typically, the employer will retain and pay for counsel, even if the professional is named as a defendant.

# Conclusion: From Daunting to Rewarding

While the array of legal issues can seem daunting, playing an active role in understanding and structuring the legal constraints and opportunities impacting one's career can be intellectually stimulating and professionally rewarding.

# A Roadmap for Success

This introductory roadmap should eliminate some of the mystery surrounding these legal puzzles.

It provides guidance for engineers to cooperate with attorneys, converting legal situations into professional benefits and strategic advantages for their employer.

# Part 2: Moral and Ethical Issues in the Development of Biomaterials and Medical Products


An Examination of the Ethical Dimensions in Bioengineering

# Introduction: Engineering vs. Medical Ethics

Engineering ethics often takes a classical "preventive ethics" approach, focusing on safety, standards, and regulation to prevent product failure.

In contrast, medical ethics, while valuing safety, emphasizes core values in decision-making and respect for patient autonomy and wellbeing, as it deals with the treatment of individuals.

# The Need for an Integrated Approach

The development of novel medical products requires a blended ethical perspective. Those involved, whether scientifically or medically oriented, must consider ethical issues arising from both the engineering and medical aspects of a product.

# Emerging Ethical Frontiers

As medical products incorporate living components, use controversial methods like gene editing, or become more advanced, the need for discussion of previously unrecognized ethical issues will only increase.

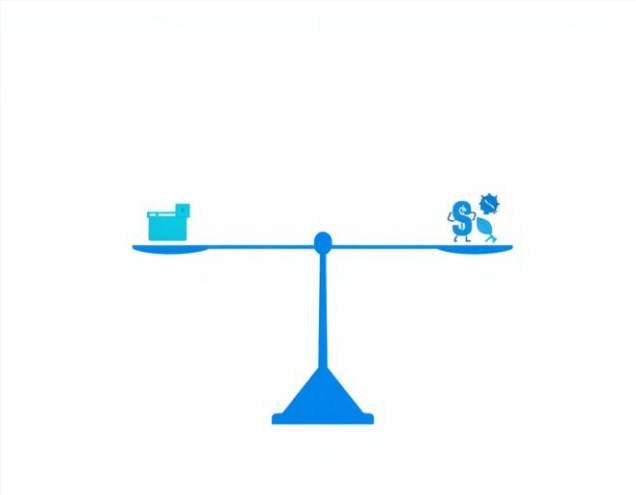
This chapter serves as a starting point for the study and discussion of the myriad ethical issues associated with the development of medical products.

# Selected Approaches to Ethical Reasoning

To discuss ethical decision-making, it is useful to define a set of methodologies for assessment.

It is important to note that moral and ethical issues often arise when there is a divergence between these approaches, and decision-making becomes simplified when they converge.

# The Utilitarian Approach



In simplest terms, a utilitarian approach favors a decision that does the most good or prevents the most harm.

This approach is widely used in engineering and business and often includes a cost-benefit or risk-benefit analysis.

# Complexities of Utilitarianism

While simple in theory, this approach can be complex in practice. It is often difficult to define what represents a "good" outcome and for whom, particularly when dealing with human health.

For example, is a good outcome one that provides the best treatment for patients, or one that maximizes profit for the company?

# The Rights Approach

By contrast, the rights approach favors decisions that protect and respect the moral rights and autonomy of individuals.

It is based on the idea that human beings have inherent worth and dignity, and should not be used as a means to an end. This is the foundation for rules governing clinical trials and informed consent.

# Conflicts in the Rights Approach

At times, these rights can come into conflict with the rights of other stakeholders, such as a provider's right to refuse a request.

The rights approach can also conflict with the utilitarian approach, for instance, when a patient cannot afford a treatment or when allocating scarce resources like organ transplants.

# The Justice Approach

The justice (or fairness) approach favors decisions that lead to the equitable distribution of access, benefits, and the potential burdens of care across society.

It requires avoiding discrimination in clinical trial subject selection and seeks to protect those with diminished autonomy.

# Justice in Practice: UNOS

An example is the United Network for Organ Sharing (UNOS), which allocates transplant organs in the U.S. largely based on urgency and geography.

The intent is to maximize the organ supply while improving access, but whether the system is truly equitable for all stakeholders remains a subject of debate.

# The Virtue Approach

The virtue approach favors actions that align with certain ideals or virtues, such as honesty, integrity, and compassion. It focuses on the character of the professional.

This approach derives from the trust that the public places in scientists and medical professionals and is central to discussions of professional responsibility and scientific integrity.

# The Paramount Importance of Safety

The safety of the public and the wellbeing of patients are paramount in both engineering and medical ethics. This is a foundational concern in all professional codes of ethics.

Practically, the safety of novel medical products is evaluated using guidelines established by regulatory bodies like the U.S. Food and Drug Administration (FDA).

# Regulatory Framework for Safety

FDA guidelines provide a set of tests which, if successfully completed, provide a reasonable expectation of safety. The specific testing depends on the product's design, components, and intended use.

Testing adheres to standards (e.g., ASTM, ISO) and practices like Good Laboratory Practice (GLP) and Good Manufacturing Practice (GMP) to ensure quality and reproducibility.

# Where Ethical Issues Arise in Safety Testing

While the existence of safety standards is a regulatory matter, the process of testing gives rise to many ethical issues.

These issues emerge particularly during testing performed in animals and humans, as well as in the interpretation and reporting of the resulting data.

# Animal Testing: A Critical Tool

It is difficult to foresee how a device will interact with the complex systems of the human body. Therefore, animal models are critical tools to assess toxicity, biocompatibility, safety, and potential effectiveness before human testing.

# The Moral Debate on Animal Research

General opinion leans toward accepting animal research as morally allowable, but there is significant opposition.

- Some argue animals have the same moral standing as humans, prohibiting most research.
- A utilitarian stance suggests animal physiology is too different from humans for the results to be applicable.

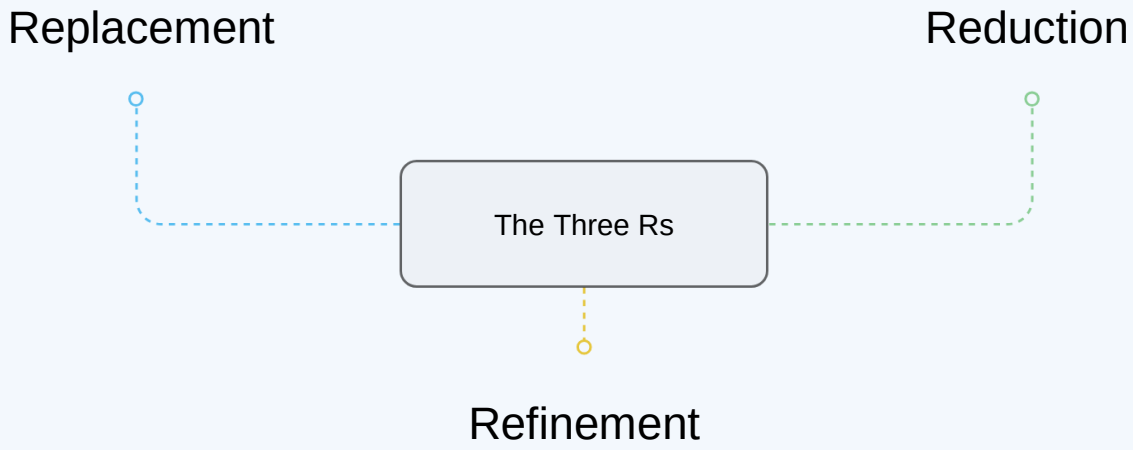
# A Tempered View: Humane Treatment

A more tempered and widely held view recognizes that animal experimentation is necessary but that animals under our care should be treated as ethically and humanely as possible.

This includes providing adequate housing, nutrition, and enrichment, while alleviating pain, stress, and suffering to the greatest extent possible.

# Framework for Ethical Animal Research: The Three Rs

In 1959, Russell and Burch introduced the concept of "The Three Rs" as a practical framework for minimizing animal usage and ensuring adequate care in experimental design.



# The First R: Replacement

Replacement refers to using an alternative strategy for an experiment that would otherwise use animals.

- Using computer simulations or in vitro cell culture experiments.
- Replacing a higher-order, more sentient animal species with one shown to have lower pain perception (e.g., a vertebrate with an invertebrate).

# The Second R: Reduction

Reduction refers to a strategy that optimizes the amount of information obtained per animal, thereby minimizing the total number of animals needed.

For example, using a longitudinal cohort of animals to generate many data points per animal uses fewer animals than a study requiring a unique animal for every time point.

# The Third R: Refinement

Refinement refers to strategies aimed at decreasing the potential pain or distress an animal may encounter.

- Using a newer, less invasive surgical technique with a shorter recovery time.
- Modifying a pain management dosing schedule to better control post-procedural pain.

# U.S. Regulatory Oversight of Animal Research

In 1966, Congress passed the Laboratory Animal Welfare Act (AWA), the first law dictating policies on the treatment of animals for research.

A 1985 amendment mandated that research institutions establish Institutional Animal Care and Use Committees (IACUCs) to review and approve proposed research using live animals covered under the Act.

# Additional Protections for Animal Subjects

While the AWA is limited to certain species, federally funded facilities are also required to have oversight of uncovered animals (like rodents and birds) under the Public Health Service (PHS) Policy on Humane Care and Use of Laboratory Animals.

This policy requires adherence to the "Guide for the Care and Use of Laboratory Animals."

# Human Testing: The Final Stage

Human clinical trials are the final stage for testing the safety and efficacy of novel medical products that have shown sufficient promise in preclinical testing.

Historically, guidance for conducting human subject research was often derived in reaction to unethical clinical studies.

# Historical Foundation: The Nuremberg Code

The first of these reactionary ethical codes was the Nuremberg Code, a set of principles used to try Nazi physicians accused of unethical human experimentation.

It contains 10 principles with a strong focus on informed patient consent without coercion, scientifically sound design, and beneficence toward participants.

# Case Study in Unethical Research: The Tuskegee Study

The "Tuskegee Study of Untreated Syphilis in the Negro Male" lasted 40 years. During this time, participants were never fully informed of the study's purpose or risks.

Crucially, they were never offered penicillin as a treatment for their syphilis after it became available in 1947. This led to public outcry upon its discovery in 1972.

# The Belmont Report: Core Ethical Principles

In response to Tuskegee, the National Commission published the Belmont Report in 1979. It established three fundamental principles for ethical human subjects research in the United States.

Respect for Persons

Beneficence

Justice

# Belmont Principle 1: Respect for Persons

This principle concerns respecting and protecting the autonomy of subjects. It is achieved by providing a truthful, comprehensive view of the study design and all associated risks.

Presenting this information without coercion forms the basis of informed consent, an essential feature of modern clinical trials.

# Belmont Principle 2: Beneficence

This principle is philosophically similar to the Hippocratic Oath, particularly the idea to "do no harm" while maximizing the quality of care.

It also dictates the cessation of clinical trials that induce undue stress or unanticipated negative health consequences in participants.

# Belmont Principle 3: Justice

This principle demands a just study, particularly regarding equal recruitment across population groups without exploiting disadvantaged populations.

Compensation for participants should be sufficient for their time, equally distributed, and proportional to the risks involved.

# International Guidelines: The Declaration of Helsinki

First published in 1964 and refined since, the Declaration of Helsinki outlines basic principles for ethical human subjects research worldwide.

It covers patient recruitment, risk management, privacy, informed consent, and the critical importance of independent review by research ethics committees.

# Institutional Review Boards (IRBs)

In the United States, any human research study supported by federal funding must be submitted to an Institutional Review Board (IRB) for review.

The IRB analyzes the proposal for scientific validity, patient enrollment mechanisms, data protection, and plans for adverse events, ensuring compliance with the Belmont principles.

# IRB Composition and Responsibility

An IRB must have at least five members, including a scientist, a nonscientist, and a community member with no affiliation to the institution, and all must be free of conflicts of interest.

Following approval, the IRB is responsible for monitoring the ongoing study for compliance and safety, with the authority to terminate a study if necessary.

# Research Integrity: The Researcher's Obligation

Research integrity is an individual's obligation to honestly apply their knowledge, tools, and expertise to answer a research question in a professional and ethical manner.

It also dictates fair, non-biased interpretation and dissemination of results.

# The Importance of Research Integrity

Science is built upon prior work. Honest and non-misleading data collection and dissemination are essential for results to be applicable, repeatable, and verifiable by others.

This builds trust within the scientific community and, just as importantly, prevents the erosion of public trust.

# Consequences of Lacking Integrity

Disseminating misleading or falsified data can erode public trust, stall research progress, and, most seriously, introduce complications and loss of life in vulnerable patient populations who believed they stood to benefit from the technology.

# Conflict of Interest: A Threat to Integrity

A conflict of interest is an interest that tends to make one's judgment less likely to benefit the patient than the patient is justified in expecting.

In research, this can include financial incentives like patent authorship, equity ownership, or funding from a company, which might influence the accurate reporting and interpretation of data.

# The Balance: Collaboration vs. Conflict

There are clear benefits to academic-industry partnerships, including advancing new products, economic growth, and improved patient care.

However, these benefits must be balanced against the potential negative impacts on research quality and reporting. This requires monitoring, management, and disclosure.

# Managing Conflicts of Interest

Most federal sponsors, research institutions, and scientific journals require monitoring and disclosure of conflicts of interest.

The Physician Payments Sunshine Act requires manufacturers to disclose payments to physicians and teaching hospitals. These measures are needed to protect research integrity and human health.

# Emerging Ethical Issues in Medical Product Development

New technological developments come with new ethical issues for which regulatory or standard guidelines may not yet exist.

As biomaterials expand to include cells, human-derived materials, or genome-modifying agents, new ethical questions have emerged.

# Ethical Issues in Stem Cell Research

The enormous therapeutic potential of stem cell research is contrasted by staunch opposition, most notably to human embryonic stem (ES) cell research.

Views are driven by personal morality, cultural norms, and religious beliefs, and a consensus on the ethical issues has yet to be reached.

# The Core Dilemma of ES Cells

The major ethical issue in ES cells relates to their origin: the inevitable destruction of a human embryo in the process of isolation.

This creates a conflict between the goal of alleviating suffering and the moral belief, shared by many, that destroying an embryo is equivalent to ending a human life.

# Ethics of Other Stem Cell Sources

- **Somatic Cell Nuclear Transfer (Cloning):** Raises ethical objections and questions about the moral status of cloned embryos.
- **Induced Pluripotent Stem (iPS) Cells:** Bypasses embryo destruction but has its own issues, including scientific uncertainty, potential tumorigenicity, and issues with informed consent.
- **Adult/Cord Blood Stem Cells:** Associated with fewer ethical objections.

# Donor Tissue and Genetic Information

Beyond the stem cells themselves, ethical concerns arise around human donor tissues. A commercial market for tissues creates a potential conflict between altruism and profitability, and may lead to inadequate protection of the donor.

Another area of concern is the ownership of genetic information versus its use for biomedical research, which requires strict confidentiality and robust informed consent.

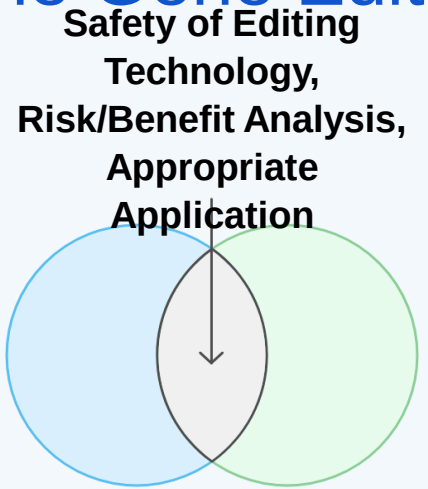
# Gene Editing and Gene Therapy

Gene therapy refers to using genetic material to cure or treat a disease. Recent approaches like CRISPR-Cas9 allow for specific alterations to a cell's genome.

As a relatively young field, researchers are still working to determine the safety of many strategies before efficacy can be fully tested.

# Somatic vs. Germline Gene Editing

Somatic Cell Editing




Germline Cell Editing

Somatic cell edits are non-heritable and affect only the individual. Germline edits are passed to offspring, raising a significant ethical dilemma about who provides consent for future generations.

# The Ethical Dilemma of Germline Editing

Who is responsible for providing informed consent for therapies that affect both an individual and their yet-to-be-born offspring? Considerable debate is ongoing.

One could argue the principle of beneficence dictates using these tools to avoid suffering from heritable, lethal pathologies. However, the long-term, generational consequences remain unknown.

# The Boundary of Enhancement

A final ethical consideration for all gene therapy is its application. There is a critical need to ensure one is not crossing the boundary from essential medical therapy into non-essential gene therapeutics.

This refers to editing genes in a healthy individual for the purpose of ability enhancement or personal enrichment.

# Cost and Access to Medical Products

Justice-based ethics argues for equal access to high-quality care, while a rights-based approach suggests patients have a right to choose their treatment.

However, these approaches conflict with the reality of healthcare economics and the ever-increasing costs of care, forcing a limit on the value placed on an individual's health.

# The Role of New Technology in Rising Costs

In the United States, healthcare costs represent nearly 20% of GDP. It is estimated that 40-50% of the annual increase in cost comes from the introduction of new medical technologies.

While these technologies improve outcomes, some argue cost control is needed, which may require limiting the use of expensive products.

# Case Study: Sofosbuvir for Hepatitis C

Introduced in 2013, sofosbuvir is a highly effective cure for hepatitis C. Its cost of over $80,000 per course in the U.S. (approx. $1000 per pill) created a significant access problem, especially for Medicaid populations where the disease is more prevalent.

# Utilitarianism vs. Rights in Practice

High prescription rates led some states to enact new coverage criteria, limiting access based on factors like disease severity and psychosocial readiness. From a utilitarian standpoint, these restrictions were needed to sustain Medicaid programs. However, they run contrary to the belief that all patients have a right to receive life-restoring treatments.

# The Pricing Debate

This issue raises the question of whether companies should be able to charge high prices for life-saving treatments. This must be balanced against the utilitarian view that strong economic incentives are necessary for companies to take the significant risks involved in new technology development.

# Conclusion: Navigating the Ethical Landscape

The primary moral and ethical issue in medical product development is protecting patient safety and wellbeing. However, achieving this involves navigating complex issues in animal and human testing, research integrity, and conflicts of interest.

# The Evolving Frontier

With increasingly novel designs, from stem cells to gene editing, the type and number of ethical issues have increased. Cost and access also raise significant moral challenges.

Those involved in the development of medical products must be familiar with pertinent ethical issues and stay informed of developing issues in their field to increase the safety and effectiveness of their work.