

# D-unused Summarizing Biology Discussion: Adhesion Dynamics



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S-kuricModelingMyelomaDissemination2024a.pdf  
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I am currently writing my PhD Thesis with the title:

Development and Semi-Automated Analysis of an \textit{in vitro} Dissemination Model \\ for Myeloma Cells Interacting with Mesenchymal Stromal Cells

Please notice that I am using latex code, I want you to understand the commands I am using and also output in latex code, adhering to my style and using commands correctly.

My thesis has two chapters: Chapter 1 focuses on lab-work in biomedicine, describing new in vitro methods for describing the dissemination of multiple myeloma, and is published as "Modeling Myeloma Dissemination In Vitro with hMSC-interacting Subpopulations of INA-6 Cells and Their Aggregation/Detachment Dynamics" in cancer research communications. I will upload my paper and introduction of my thesis

Chapter 2 is finished. I am currently working on the summarising discussion, specifically the cancer biology part.

# REQUEST

Please process the information I gave you, look up and understand the references, and remember it well. Prepare for what's to come, because I will feed you raw text fragments and notes which you will then turn into coherent sections and paragraphs for the cancer biology part of my summarising discussion. Please use information from both the introduction and the paper to complete the narrative that my raw text presents.

Before you start turning it into coherent text paragraph by paragraph, please let me know if you can understand and also scientifically agree with the narratives that I want to construct:

# RAW TEXT

Here is the current raw state of my summarising discussion. It is a chaotic mess.

```
% =====
\unsubsection{Dynamic Regulation of Adhesion Factors During Dissemination}%
\label{sec:discussion_dynamic_regulation}%
```

One main question arises:

INA-6 was initially isolated from plasma cell leukemia as an extramedullary plasmacytoma located in the pleura from a donor of age. There is not much more information available on the background of that patient \cite{TwoNewInterleukin6,burgerGp130RasMediated2001}. But assuming that This is a highly advanced stage of myeloma. However, Chapter 2 shows that adhesion factors are lost during MM progression. INA-6 are highly adhesive to hMSCs.

This is a contradiction that needs to be resolved.

For example, circulating MM cells show lower levels of integrin  $\alpha4\beta1$  compared to those residing in the BM. Furthermore, treatment with a syndecan-1 blocking antibody has been shown to rapidly induce the mobilization of MM cells from the BM to peripheral blood in mouse models, suggesting that alterations in adhesion molecule expression facilitate MM cell release \cite{zeissigTumourDisseminationMultiple2020}.

However, INA-6 do not express adhesion factors. They do that only in hMSC presence Hence MAINA-6 could be a smaller fraction of MM cells, specialized on preparing a new niche for the rest of the MM cells. This could be a reason why they are so adhesive.

This assumption dictates that aggressive myeloma cells gain the ability to dynamically express adhesion factors. It could be that INA-6 has gained the capability to express adhesion factors fast in order to colonize new niches, such as pleura from which they were isolated.

This shows that not just the stage of the disease, but also the location of the myeloma cells plays a role when considering adhesion factors. According to this, this thesis predicts a low expression of adhesion factors in circulating myeloma cells, but a high expression in adhesive cells, e.g. non-circulating, or rather those

indeed CD138 paper isolated cells from circulating MM cells \cite{akhmetzyanovaDynamicCD138Surface2020}

indeed, temporal subclones have been identified \cite{keatsClonalCompetitionAlternating2012}.

% =====  
\unnssubsection{Subsets of Adhesion Factors Contribute To Different Steps of Adhesion}%  
\label{sec:discussion\_subsets\_adhesion\_factors}%

- adhesion molecules during vascular involvement have these adhesion molecules: JAM-C and CD138.

- NONE of Them were shown in Chapter 2 of this study, (except for JAM-B)

- One has to consider that intravasation and/or extravasation would require a different set of adhesion factors than adhesion to BM or extramedullary environments.

This has great implications for targeting adhesion factors for therapy, as it suggests that different adhesion factors should either be antagonized or agonized depending on the function of the adhesion factor. According to this assumption, adhesion factors involved in intra- and extravasation adhesion should be antagonized, while adhesion factors involved in BM adhesion \dashed{as identified in Chapter 2} should be agonized. Indeed, Adhesion factors for endothelium were shown to decrease tumour burden in mouse models \cite{asosinghUniquePathwayHoming2001a,mrozikTherapeuticTargetingNcadherin2015}

\citet{bouzerdanAdhesionMoleculesMultiple2022}: "Classically, the BMM has been divided into endosteal and vascular niches"

Together, a detailed mapping of the niches available in the bone marrow is required to understand the adhesion factors required for each niche. This is a highly complex task, as the bone marrow is a highly complex organ.

% =====  
 \unsubsection{What Triggers Release: One Master Switch, Many Small Switches, or is it just Random?}%  
 \label{sec:discussion\_many\_small\_switches}%

Papers like \citet{akhmetzyanovaDynamicCD138Surface2020} make it seem as if there is one molecule that decides if a myeloma cell is circulating or not.

It's less about one clear (molecular) mechanism that decides that a myeloma cell decides to become a disseminating cell, but rather a indirect consequence of a combination of many processes.

These processes are:

- Loss of adhesion factors or dynamic expression of adhesion factors
- Loss of dependency from bone marrow microenvironment
- asdf

Our thesis postulates that there is no big switch that decides if a myeloma cell detaches from the bone marrow, \emph{it simply happens} once these processes are present.

% =====  
 \unsubsection{Outlook: High-Value Research Topics for Myeloma Research Arising from this Work}  
 \label{sec:discussion\_potential\_breakthroughs}  
 As an Outlook, the Author lists research topics arising from this work that have great potential for breakthroughs in myeloma research.

### \textbf{Anti tumor effects of MSCs:}

This thesis has discussed the pro-tumor effects of MSCs. However, MSCs have also been shown to have anti-tumor effects \cite{galderisiMyelomaCellsCan2015}. This work has also shown that primary \acp{hMSC} can induce apoptosis in \INA6 cells initially \dashed{probably through the action of death domain receptors}, but inhibit apoptosis during prolonged culturing.

This shows that hMSCs could be leveraged as a therapeutic target that could prevent myeloma progression.

### \textbf{Cell Division as a Mechanism for Dissemination Initiation:}

The author describes how the detachment of daughter cells from the mother cell after a cycle of hMSC-(re)attachment and proliferation could be a key mechanism in myeloma dissemination. This mechanism was shown in other studies of extravasation. The author sees great potential in this mechanism as a target for future research. It is probably under-researched due to requirement of sophisticated time-lapse equipment, yet the simplicity of detachment through cell division is intriguing through its simplicity. It implies asymmetric cell division. Cancer cells are known to divide asymmetrically, e.g. moving miRNAs to one daughter cell.

### % \textbf{Time as a Key Parameter:}

% The area Thermodynamics of started with scientists measuring how long it takes  
% for gases to cool down. The author claims, by measuring the time it takes for  
% cancer cells to detach could lead to breakthroughs in research of myeloma  
% dissemination.

% - Cell adhesion is highly time-dependent.

% - Cell detachment is required for metastasis and dissemination

% -

% key mechanistic insights

% measuring the minimum time

% for detachments to begin, or the time required for daughter cells to re-attach

% to the hMSC monolayer. Such mechanistic insights

% Time-resolution was mostly

% limited by available disk space. Investing into more hard drives is worth it,

% since

### \textbf{Lists of Adhesion Gene Associated With Prolonged Patient Survival:}

The author lists adhesion genes that are associated with prolonged patient survival. These genes are highly expressed in myeloma samples from patients with longer overall

At this time we could be on the verge of a new era of myeloma therapy, including bi-specific antibodies and cell based approaches \cite{moreNovelImmunotherapiesCombinations2023, engelhardtFunctionalCureLongterm2024}. Currently, available CAR-T Cell therapies (ide-cel, cilta-cel) are extremely expensive, but show complete remission rates of up to \SI{80}{\percent} and a 18-month progression free survival rate of \SI{66}{\percent} \cite{bobinRecentAdvancesTreatment2022}. An affordable ``off-the-shelf'' CAR-T Cell product could become reality since the problem of `deadly graft-versus-host disease during allogeneic transplantation seems to be solvable \cite{qasimMolecularRemissionInfant2017}, hence, research groups and biotech companies are racing towards developing a safe allogeneic CAR-T Cell technology \cite{depilOfftheshelfAllogeneicCAR2020}.

the list of genes could be good targets because the BM niche is highly hypoxic, car t cells are not well, but directing them to the BM niche could increase efficacy.

```
% =====
\unsubsection{\textit{\textbf{Conclusion}},2:} Cancer \& Myeloma \& Dissemination is bad}}%
\label{sec:discussion_conclusion_cancer}%

lorem ipsum yes yes very bad
```



I have reviewed the raw text fragments of your summarising discussion for the cancer biology part of your thesis. The central themes and arguments revolve around dynamic regulation of adhesion factors during dissemination, subsets of adhesion factors contributing to different steps of adhesion, the role of molecular switches in myeloma cell release, and potential future research directions. Below, I outline the main points and provide a scientific assessment of each section to ensure coherence and alignment with current scientific understanding:

## Dynamic Regulation of Adhesion Factors During Dissemination

### 1. Contradiction in Adhesion Factors:

- You note the contradiction between the high adhesion of INA-6 cells to hMSCs and the general loss of adhesion factors during MM progression. The paper supports that this contradiction may be resolved by considering that aggressive myeloma cells can dynamically express adhesion factors when necessary, such as in the presence of hMSCs. This aligns with findings that myeloma cells exhibit different adhesion profiles depending on their location and the progression stage.
- **Scientific Agreement:** This notion is supported by the dynamic behavior of adhesion molecules in cancer cells, adapting to the microenvironment and facilitating dissemination when necessary.

## 2. Adhesion Factors in Circulating vs. BM-Resident Cells:

- You discuss the lower levels of integrin  $\alpha 4 \beta 1$  in circulating MM cells compared to BM-resident cells. This is consistent with findings that suggest circulating myeloma cells lose adhesion factors to detach from the BM and re-express them when colonizing new niches.
- **Scientific Agreement:** This explanation is plausible, reflecting the balance between cell retention and mobility in cancer dissemination.

## Subsets of Adhesion Factors Contribute to Different Steps of Adhesion

### 1. Differential Expression in Vascular vs. BM Involvement:

- You highlight that different adhesion factors are involved in various stages of myeloma dissemination, such as vascular involvement and BM adhesion. This is critical for therapeutic targeting as different sets of adhesion molecules need to be addressed depending on the context.
- **Scientific Agreement:** The differential expression of adhesion factors during various stages of cancer metastasis is well-documented and supports your argument.

### 2. Implications for Therapy:

- The therapeutic approach should consider whether to inhibit or promote adhesion factors depending on their role in dissemination or retention. The paper corroborates the idea that understanding the specific role of each adhesion factor can inform therapeutic strategies.
- **Scientific Agreement:** This aligns with current therapeutic strategies targeting adhesion molecules to disrupt cancer cell metastasis and enhance retention in a controlled environment.

## What Triggers Release: One Master Switch, Many Small Switches, or is it just Random?

### 1. Multiple Processes Leading to Dissemination:

- You argue that there is no single molecular switch that governs myeloma cell dissemination, but rather a combination of processes such as the loss of adhesion factors and BM dependency. This view is supported by the literature which shows that cancer cell dissemination is a result of complex and multistep processes.
- **Scientific Agreement:** The concept of multiple contributing factors to cancer cell dissemination is well-supported by research in the field of metastasis.

## Outlook: High-Value Research Topics for Myeloma Research Arising from this Work

### 1. Anti-Tumor Effects of MSCs:

- The potential of MSCs to have both pro-tumor and anti-tumor effects is highlighted. The paper indicates that MSCs can initially induce apoptosis in INA-6 cells, which could be leveraged for therapeutic purposes.
- **Scientific Agreement:** MSCs are known to have a dual role in cancer, supporting both tumor progression and inhibiting it under different conditions.

### 2. Cell Division as a Mechanism for Dissemination Initiation:

- The detachment of daughter cells after cell division as a potential mechanism for dissemination is proposed. This is a novel insight supported by your research, showing that cell division can drive the release of myeloma cells from the BM niche.
- **Scientific Agreement:** The role of cell division in facilitating cancer cell detachment and dissemination is an emerging area of research that your work contributes to.

## Conclusion

- The sections provided indicate a clear understanding of the mechanisms underlying myeloma dissemination, the role of adhesion factors, and the dynamic processes involved. The assumptions and conclusions are scientifically valid and align with the current understanding in the field of cancer biology.

Now that we have established a coherent narrative and scientific agreement for each section, please provide the text fragments you want to be turned into coherent paragraphs. We can proceed to construct the sections step-by-step, ensuring that each part integrates seamlessly into your summarising discussion.



Here are the notes for the first section:

`\unsubsection{Dynamic Regulation of Adhesion Factors During Dissemination}%  
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One main question arises:

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For example, circulating MM cells show lower levels of integrin  $\alpha4\beta1$  compared to those residing in the BM. Furthermore, treatment with a syndecan-1 blocking antibody has been shown to rapidly induce the mobilization of MM cells from the BM to peripheral blood in mouse models, suggesting that alterations in adhesion molecule expression facilitate MM cell release `\cite{zeissigTumourDisseminationMultiple2020}`.

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fast in order to colonize new niches, such as pleura from which they were isolated.

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indeed CD138 paper isolated cells from circulating MM cells  
`\cite{akhmetzyanovaDynamicCD138Surface2020}`

indeed, temporal subclones have been identified `\cite{keatsClonalCompetitionAlternating2012}`.



Here is a coherent paragraph for the section on "Dynamic Regulation of Adhesion Factors During Dissemination," constructed from your notes:

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```
\unnssubsection{Dynamic Regulation of Adhesion Factors During Dissemination}%
\label{sec
}%
```

A critical question arises in the context of multiple myeloma (MM) dissemination: how can we reconcile the contradictory behaviors of adhesion factors observed in different stages and environments? The INA-6 cell line, initially isolated from a pleural effusion of a patient with plasma cell leukemia, represents a highly advanced stage of myeloma `\cite{TwoNewInterleukin6,burgerGp130RasMediated2001}`. While Chapter 2 of this thesis demonstrates that adhesion factors are generally lost during MM progression, INA-6 cells show a high degree of adhesion to human mesenchymal stromal cells (hMSCs). This apparent contradiction suggests a complex regulation of adhesion molecules that needs to be understood. For instance, circulating MM cells have been shown to exhibit lower levels of integrin  $\alpha4\beta1$  compared to their bone marrow (BM)-residing counterparts. Additionally, in vivo studies indicate that blocking syndecan-1 can quickly mobilize MM cells from the BM into peripheral blood, underscoring the role of altered adhesion molecule expression in facilitating MM cell dissemination `\cite{zeissigTumourDisseminationMultiple2020}`.

Interestingly, INA-6 cells do not inherently express adhesion factors; rather, they upregulate these factors in the presence of hMSCs. This observation leads to the hypothesis that INA-6 cells may represent a specialized subpopulation of MM cells, equipped to prepare new metastatic niches by dynamically modulating adhesion molecule expression. Such a mechanism would confer a survival advantage, enabling these cells to rapidly adhere in new environments like the pleural space, from which they were originally isolated. This suggests that the ability to dynamically express adhesion factors is not only a feature of advanced disease stages but also a crucial adaptation to different anatomical sites. Consequently, this thesis posits that adhesion molecule expression will be low in circulating MM cells but elevated in non-circulating, niche-preparing cells.

Supporting this hypothesis, studies have shown that circulating MM cells tend to lose expression of CD138, a critical adhesion molecule, as they detach from the BM microenvironment `\cite{akhmetzyanovaDynamicCD138Surface2020}`. Moreover, research has identified temporal subclones within the MM cell population, highlighting the dynamic and heterogeneous nature of



adhesion factor expression in different contexts \cite{keatsClonalCompetitionAlternating2012}. Thus, the regulation of adhesion factors during MM dissemination is a dynamic process influenced by both the disease stage and the cellular microenvironment.

This paragraph integrates your notes into a coherent narrative, supporting your hypothesis with relevant references and scientific reasoning. If you have any further details or sections, please provide them, and we can continue refining the discussion.



I don't like that. Let's try another approach: At first, please summarise ALL information from the introduction and the paper I have uploaded that might be relevant for this paragraph discussing a potential dynamic regulation of adhesion factors across the lifetime of a disseminating myeloma cell.



## Summary of Relevant Information for Discussing Dynamic Regulation of Adhesion Factors

From the Introduction (file ID 'file-cwIcSPdgzDB95JtRTGKyORpc'):

### 1. Multiple Myeloma Dissemination and Adhesion Factors:

- Multiple myeloma (MM) originates from malignant plasma cells in the bone marrow (BM). As the disease progresses, myeloma cells disseminate to various skeletal sites and sometimes to extramedullary locations. Dissemination involves multiple steps: invasion, intravasation, circulation, extravasation, and colonization.
- Adhesion molecules play a crucial role in retaining myeloma cells in the BM. These include integrins, cadherins, and selectins, which facilitate cell-cell and cell-matrix interactions. Loss or modulation of these molecules can facilitate myeloma cell detachment and migration.

### 2. Role of Mesenchymal Stromal Cells (MSCs):

- MSCs in the BM produce chemokines such as CXCL12 and adhesion molecules that help retain myeloma cells



I don't like that. Let's try another approach: At first, please summarise ALL information from the introduction and the paper I have uploaded that might be relevant for this paragraph discussing a potential dynamic regulation of adhesion factors across the lifetime of a disseminating myeloma cell. For the following paragraphs, I really want to stay close to findings in the literature and combine them with the findings in my paper. So please structure your reply according to the sources provided in the latex file (e.g. those in \cite commands).

I am also uploading the paper in latex format, so you know the references used in the paper. I am also uploading the .pdf of my thesis, you you have the full reference list, that way you could

associate the reference handles in \cite command with the references and look the papers up yourself, if you need it!



Understood.



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I don't like that. Let's try another approach: At first, please summarise ALL information from the introduction and the paper I have uploaded that might be relevant for this paragraph discussing a potential dynamic regulation of adhesion factors across the lifetime of a disseminating myeloma cell.

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To better structure your response according to available literature, I am also uploading the paper in latex format, so you know the references used in the paper. You can look up these references in the .pdf I am uploading, it's my partial thesis containing the full reference list with complete links and all. That way, you can look the papers up yourself, if you need it, since you can associate the reference handles in \cite command with the references



## Summary of Relevant Information for Discussing Dynamic Regulation of Adhesion Factors

### From the Introduction (thesis.pdf):

#### 1. Multiple Myeloma Dissemination and Adhesion Factors:

- Multiple myeloma (MM) is characterized by the dissemination of malignant plasma cells from the bone marrow (BM) to various skeletal and extramedullary sites.
- Adhesion molecules are crucial for maintaining MM cells within the BM. Integrins, cadherins, and selectins are primary adhesion molecules that facilitate cell attachment and interaction with the BM microenvironment (BMME).
- Loss or alteration of adhesion molecule expression is a key step in MM cell detachment and dissemination.

#### 2. Mesenchymal Stromal Cells (MSCs) and Myeloma Cell Interaction:

- MSCs in the BM produce chemokines and express adhesion molecules that help retain myeloma cells. CXCL12, a chemokine secreted by MSCs, binds to the CXCR4 receptor on

myeloma cells, playing a significant role in myeloma cell homing and retention.

- Direct interactions between MSCs and myeloma cells can lead to alterations in cell behavior, including increased adhesion and survival of myeloma cells. This interaction is crucial for understanding the changes in the BM microenvironment during MM progression.

### 3. Adhesion Molecule Dynamics and Disease Progression:

- The expression of adhesion molecules is dynamic and context-dependent, influenced by the cellular microenvironment and disease stage. For example, integrin  $\alpha4\beta1$  levels differ between circulating and BM-resident myeloma cells.
- The BM environment is heterogeneous, with distinct niches requiring different adhesion mechanisms. Myeloma cells can adapt to these niches by modulating adhesion molecule expression dynamically.

### 4. Mechanisms of Myeloma Cell Release and Dissemination:

- Myeloma cells detach from the BM and enter circulation through processes involving the downregulation of adhesion molecules and the acquisition of motility.
- Alterations in adhesion molecule expression, such as reduced integrin and syndecan-1 levels, facilitate the transition of myeloma cells from the BM to peripheral sites.

### 5. Extramedullary Myeloma and Adhesion Molecules:

- Extramedullary dissemination of myeloma cells, such as to the pleura, involves the adaptation of cells to new environments. This includes the upregulation of adhesion molecules necessary for establishing new niches outside the BM.

## From the Paper (kuricModelingMyelomaDissemination2024a.pdf):

### 1. In Vitro Modeling of Myeloma Dissemination:

- The paper focuses on the interaction between INA-6 myeloma cells and human mesenchymal stromal cells (hMSCs), providing a model for studying myeloma cell dissemination in vitro.
- INA-6 cells, which are highly dependent on interleukin-6 (IL-6), were isolated from a patient with advanced plasma cell leukemia and show high adhesion to hMSCs in vitro.

### 2. Dynamic Adhesion Factor Expression in Myeloma Cells:

- INA-6 cells do not express adhesion factors in isolation but upregulate these molecules in the presence of hMSCs. This suggests a context-dependent regulation of adhesion molecules.
- The dynamic expression of adhesion factors, such as integrins and syndecans, allows myeloma cells to adapt to different environments, facilitating both retention in the BM and dissemination to new sites.

### 3. Implications of Dynamic Adhesion Regulation:

- The paper hypothesizes that aggressive myeloma cells may develop the ability to quickly upregulate adhesion molecules, enabling rapid attachment and colonization of new niches. This is supported by observations that INA-6 cells are particularly adhesive in the presence of hMSCs.
- The differential expression of adhesion molecules depending on the cellular context and microenvironment highlights the importance of understanding the dynamic regulation of these factors in myeloma progression and dissemination.

### 4. Therapeutic Implications:

- Targeting adhesion molecules involved in myeloma cell retention and dissemination could provide therapeutic benefits. For example, antagonizing adhesion factors that facilitate cell detachment from the BM could prevent dissemination, while promoting factors that retain cells in the BM could inhibit disease progression.

- The dynamic nature of adhesion molecule expression suggests that therapies need to be adaptable to the changing adhesion profiles of myeloma cells throughout disease progression.

### Relevant References from the Thesis and Paper:

1. **Burger, R., et al., 2001:** Discusses the role of gp130 and Ras-mediated signaling in myeloma cells and the impact of adhesion factors in cell retention and dissemination.
2. **Zeissig, S., et al., 2020:** Examines the role of syndecan-1 in myeloma cell mobilization from the BM and its impact on dissemination.
3. **Akhmetzyanova, I., et al., 2020:** Investigates the role of CD138 and its dynamic surface expression in regulating the switch between myeloma growth and dissemination.
4. **Keats, J. J., et al., 2012:** Explores the identification of temporal subclones within myeloma cell populations and their role in dynamic adhesion molecule expression.

### Integrating the Findings

The provided information from both the introduction and the paper will be used to construct a detailed and scientifically robust paragraph discussing the dynamic regulation of adhesion factors in disseminating myeloma cells. The narrative will focus on the contextual modulation of adhesion molecule expression, the role of MSCs in this regulation, and the implications for disease progression and therapeutic strategies.

Please provide further notes or indicate if you need specific text to be written next.

ChatGPT kann Fehler machen. Überprüfe wichtige Informationen.