

A formalization of one of the main claims of “The cancer glycocalyx mechanically primes integrin-mediated growth and survival” by Paszek et al. 2014¹

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Abstract. Paszek et al. claimed in previous work that glycocalyx bulk mechanically drives integrin clustering in cancer cells engaged with the extracellular matrix. We present here a formalization of that claim, stating that all things of class “glycocalyx bulk” that are in the context of a thing of class “ecm bound cancer cell” generally have a relation of type “increases” to a thing of class “integrin clustering” in the same context.

Keywords: ecm bound cancer cell, glycocalyx bulk, integrin clustering

1. Introduction

Paszek et al. [2] state that “Expression of large tumour-associated glycoproteins in non-transformed mammary cells promoted focal adhesion assembly and facilitated integrin-dependent growth factor signalling to support cell growth and survival.”. We present here a formalization of the main scientific claim from this quote by using a semantic template called the super-pattern [1].

2. Formalization

Our formalization looks as follows:

¹As RDF/nanopublication: <http://purl.org/np/RAoo8EvTgfkxJw5SgZXbJvRI5nQG7ygeGaHp8Zud1U4Zw>

CONTEXT-CLASS (“in the context of all. . .”):	ecm bound cancer cell
SUBJECT-CLASS (“things of type. . .”):	glycocalyx bulk
QUALIFIER:	generally
RELATION-TYPE (“have a relation of type. . .”):	increases
OBJECT-CLASS (“to things of type. . .”):	integrin clustering

In the context class we use a new minted class “ecm bound cancer cell” that is a subclass of “cancer cell” (Q4118072) from Wikidata and is related to the class “extracellular matrix” (Q193825) from Wikidata. In the subject class, we use a new minted class “glycocalyx bulk” that is related to the class “glycocalyx” (Q898356) from Wikidata. In the object class we minted a new class “integrin clustering” that is a subclass of “integrin binding” (Q14633861) from Wikidata and is related to the class “focal adhesion” (Q904514) from Wikidata.

3. RDF code

This is our formalization as a nanopublication in TriG format:

```
@prefix this: <http://purl.org/np/RAoo8EvTgfkxJw5SgZXbJvRl5nQG7ygeGaHp8Zud1U4Zw> .
@prefix sub: <http://purl.org/np/RAoo8EvTgfkxJw5SgZXbJvRl5nQG7ygeGaHp8Zud1U4Zw#> .
@prefix np: <http://www.nanopub.org/nschema#> .
@prefix dct: <http://purl.org/dc/terms/> .
@prefix nt: <https://w3id.org/np/o/ntemplate/> .
@prefix npx: <http://purl.org/nanopub/x/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix orcid: <https://orcid.org/> .
@prefix prov: <http://www.w3.org/ns/prov#> .
@prefix sp: <https://w3id.org/linkflows/superpattern/terms/> .

sub:Head {
  this: np:hasAssertion sub:assertion ;
  np:hasProvenance sub:provenance ;
  np:hasPublicationInfo sub:pubinfo ;
  a np:Nanopublication .
}
sub:assertion {
  sub:spi a sp:SuperPatternInstance ;
  rdfs:label "Glycocalyx bulk mechanically drives integrin clustering in cancer cells engaged with the extracellular matrix" ;
  sp:hasContextClass <http://purl.org/np/RAoAF90U6YxAvnchfj0dRtT5HRz320Pz202aGap-VfuI#ecm-bound-cancer-cell> ;
  sp:hasSubjectClass <http://purl.org/np/RA-jkb7qPNTSOe_EXltW_rlQWQ9x3_Y1KOzW6J_bbPz4U#glycocalyx-bulk> ;
  sp:hasQualifier <https://w3id.org/linkflows/superpattern/terms/generallyQualifier> ;
  sp:hasRelation <https://w3id.org/linkflows/superpattern/terms/increases> ;
  sp:hasObjectClass <http://purl.org/np/RAF8AVn-wnTcSGxvPZ1Uiy_AtOhINlynnAxxiCdcTvwu#integrin-clustering> .
}
sub:provenance {
  sub:activity a sp:FormalizationActivity ;
  prov:used sub:quote , <https://www.nature.com/articles/nature13535> ;
  prov:wasAssociatedWith orcid:0000-0002-0830-7029 .
  sub:assertion prov:wasGeneratedBy sub:activity .
  sub:quote prov:value "Expression of large tumour-associated glycoproteins in non-transformed mammary cells promoted focal adhesion assembly and facilitated integrin-dependent growth factor signalling to support cell growth and survival." ;
  prov:wasQuotedFrom <https://www.nature.com/articles/nature13535> .
}
sub:pubinfo {
  sub:sig npx:hasAlgorithm "RSA" ;
  npx:hasPublicKey
  "MIGfMA0GCSqGSIb3DQEBAQUAA4GNADCBiQKBgQCluZ2msgo7OqPkyRoZmluzpaLX8KRHyDs3J/cZwm6+Vq/CKVIGsGaT7/XH435cB9J8dwCgQ/Jssj1j6oqX+nSI9x
  XbtMH9ZeyGHFBzK1cUBy/rRSez4EnwbS1sKMBSc4MBCXQ9R3jZ3GpsN0GmIrS1ukKkUBQrREBYpb4w5MbGywIDAQAB" ;
  npx:hasSignature
  "Mc6yNlLGIu3AnhZEmrajdDXbYISe2imFa80BDFBIWbQvJlOdxKaohx+dr9jwbzecksZ+bMnvt0jD/ftMxBeLu3126L1DmW0kxIWoTvfI+RRhegaXTkRT/RV7EB
  mCuEfzEU6Lk3YkK/v4d0iCP24meilYLdsNRLK4n44AvOr541E=" ;
  npx:hasSignatureTarget this .
  this: dct:created "2021-11-26T17:14:38.341-07:00"^^xsd:dateTime ;
  dct:creator orcid:0000-0002-0830-7029 ;
}
```

```

npx:introduces sub:spi ;
npx:supersedes <http://purl.org/np/RAh1GOK4_HhqeUeJhIyV_DDCFFTY9jeeiKWgBSzooWEi4> ;
<https://w3id.org/linkflows/reviews/isUpdateOf> <http://purl.org/np/RASZZ5T1Ca5gpCMPubKoypr_0WcSUKHiMaADu9o1BS1Xs> ;
nt:wasCreatedFromProvenanceTemplate <http://purl.org/np/RAE1wniOyOy039P1K9QkQ-wqbC3g-R2nXraP5huu8W39k> ;
nt:wasCreatedFromPubinfoTemplate <http://purl.org/np/RA2vCBXZf-icEcVRGhulJXugTGxpsV5yVr9yqCI1bQh4A> ,
<http://purl.org/np/RAA2MfgdBCzmz9yVWjKLNbyfBNcwsMmOgcNUxkk1maIM> ,
<http://purl.org/np/RAjpbMlW3owYhJUBo3DtsuDLXsNAJ8cnGeWAutDVjuAuI> ;
nt:wasCreatedFromTemplate <http://purl.org/np/RAv68imZrEjfcP2rmEg1hzoBqEvc0cQMtp9_1Za0BxNM4> .
}

```

The following nanopublications introduce the newly minted classes in TriG format.
This is the class definition of “ecm bound cancer cell”:

```

@prefix this: <http://purl.org/np/RAaOAF90U6YxAvnchfj0dRtT5HRz320Pz202aGap-VfuI> .
@prefix sub: <http://purl.org/np/RAaOAF90U6YxAvnchfj0dRtT5HRz320Pz202aGap-VfuI#> .
@prefix np: <http://www.nanopub.org/nschema#> .
@prefix dct: <http://purl.org/dc/terms/> .
@prefix nt: <https://w3id.org/np/o/ntemplate/> .
@prefix npx: <http://purl.org/nanopub/x/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix orcid: <https://orcid.org/> .
@prefix prov: <http://www.w3.org/ns/prov#> .
@prefix skos: <http://www.w3.org/2004/02/skos/core#> .

sub:Head {
  this: np:hasAssertion sub:assertion ;
  np:hasProvenance sub:provenance ;
  np:hasPublicationInfo sub:pubinfo ;
  a np:Nanopublication .
}

sub:assertion {
  sub:ecm-bound-cancer-cell a <http://www.w3.org/2002/07/owl#Class> ;
  rdfs:label "cancer cell engaged in extracellular matrix" ;
  rdfs:subClassOf <http://www.wikidata.org/entity/Q4118072> ;
  skos:definition "cancer cell engaged in extracellular matrix" ;
  skos:relatedMatch <http://www.wikidata.org/entity/Q193825> .
}

sub:provenance {
  sub:assertion prov:wasAttributedTo orcid:0000-0002-0830-7029 .
}

sub:pubinfo {
  sub:sig npx:hasAlgorithm "RSA" ;
  npx:hasPublicKey
  "MIGfMA0GCsQGSIB3DQBEAQUAA4GNADCBiQKBgQC1uZ2msgo7OqPkyRoZmluzpaLX8KRHyDs3J/cZwm6+Vq/CKVIGsGaT7/XH435cE9J8dwCgQ/Jssj1j6oqX+nSI9X
  XBtMH9ZeyGHFBzKicUByrRSez4EnwS1sKMBSc4MBCXQ9R3jZ3GpsN0GmIrSlukKkUBQREBYpb4w5MbGyWIDAQAB" ;
  npx:hasSignature
  "J5J3Blgx/OmReiNFC8+4TzqHm34UUmKcQKRhq7SVPq5H0rLE0fgyX4RfZfA0oQg5dfD7vnbVttaGsUQZs1Iw1dU4r/CYko2IXUQiptdcY28cR76t/4coiBcFCZpgy
  3GPTKwIj7uR/aJIUj4UDzA6LcMsWju0hT1bp5NDmNht+8E=" ;
  npx:hasSignatureTarget this: .
  this: dct:created "2021-11-12T09:21:35.816-08:00"^^xsd:dateTime ;
  dct:creator orcid:0000-0002-0830-7029 ;
  npx:introduces sub:ecm-bound-cancer-cell ;
  npx:supersedes <http://purl.org/np/RAXecDWH8gZVp7FZRP1m_Fg6EXH_uoZGhKN9blfN9lrFI> ;
  <https://w3id.org/linkflows/reviews/isUpdateOf> <http://purl.org/np/RAXecDWH8gZVp7FZRP1m_Fg6EXH_uoZGhKN9blfN9lrFI> ;
  nt:wasCreatedFromProvenanceTemplate <http://purl.org/np/RANwQa4ICWS5SOjw7gp99nBpXBasapwtZF1fIM3H2gYTM> ;
  nt:wasCreatedFromPubinfoTemplate <http://purl.org/np/RAA2MfgdBCzmz9yVWjKLNbyfBNcwsMmOgcNUxkk1maIM> ,
  <http://purl.org/np/RAOGu9Lh0BD4tbIRB9RG6RGRA_Obdh75NTbIqaWgxxs8M> ,
  <http://purl.org/np/RAjpbMlW3owYhJUBo3DtsuDLXsNAJ8cnGeWAutDVjuAuI> ;
  nt:wasCreatedFromTemplate <http://purl.org/np/RAqpgRpigXtt8iPV9uOpf3wIT3qz0I8Sg2Q72CNV8g-Yo> .
}

```

This is the class definition of “glycocalyx bulk”:

```

@prefix this: <http://purl.org/np/RA-jkb7qPNTSOe_EX1tW_r1QWQ9x3_Y1KOzW6J_bbPz4U> .
@prefix sub: <http://purl.org/np/RA-jkb7qPNTSOe_EX1tW_r1QWQ9x3_Y1KOzW6J_bbPz4U#> .
@prefix np: <http://www.nanopub.org/nschema#> .
@prefix dct: <http://purl.org/dc/terms/> .
@prefix nt: <https://w3id.org/np/o/ntemplate/> .
@prefix npx: <http://purl.org/nanopub/x/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .

```

```

@prefix orcid: <https://orcid.org/> .
@prefix prov: <http://www.w3.org/ns/prov#> .
@prefix skos: <http://www.w3.org/2004/02/skos/core#> .

sub:Head {
  this: np:hasAssertion sub:assertion ;
  np:hasProvenance sub:provenance ;
  np:hasPublicationInfo sub:pubinfo ;
  a np:Nanopublication .
}
sub:assertion {
  sub:glycocalyx-bulk a <http://www.w3.org/2002/07/owl#Class> ;
  rdfs:label "glycocalyx bulk" ;
  skos:definition "Relating to size, density, or bulk of the glycocalyx" ;
  skos:relatedMatch <http://www.wikidata.org/entity/Q898356> .
}
sub:provenance {
  sub:assertion prov:wasAttributedTo orcid:0000-0002-0830-7029 .
}
sub:pubinfo {
  sub:sig npx:hasAlgorithm "RSA" ;
  npx:hasPublicKey
"MIGfMA0GCgGSIb3DQEBAQUAA4GNADCBiQKBgQCluZ2msgo7OqPkyRoZmluzpaLX8KRHyDs3J/cZwm6+Vg/CKVIGsGaT7/XH435cE9J8dwCgQ/Jssjlj6oqX+nSI9x
XBtMH9ZeyGHFBzKlCUBy/rRSez4EnwS1sKMBS4MBCXQ9R3jZ3GpsN0GmIrS1ukKkUBQrREBYpb4w5MbGywIDAQAB" ;
  npx:hasSignature
"WlbAvo5qWbVaY3li3E/uayLdSkt0IFbe2m+P7z0CEaoghb+sTAehmDjw9pmd2bzPQFblGdIwBr5yhGHXGorM4v3bkV2nIiRecOwhvtu9hM2pIUtS8QwD6kqgHsO1Wxz
T4Wqs3GmS63PgN3cxZjEs0BUtWUhiXbd2V6gkLUPvaK8=" ;
  npx:hasSignatureTarget this: .
  this: dct:created "2021-11-12T09:27:02.246-08:00"^^xsd:dateTime ;
  dct:creator orcid:0000-0002-0830-7029 ;
  npx:introduces sub:glycocalyx-bulk ;
  npx:supersedes <http://purl.org/np/RACS5sSm45MgbuJrzttnPrpdulAuLiKxDni-6JcKzN5ZtM> ;
  <https://w3id.org/linkflows/reviews/isUpdateOf> <http://purl.org/np/RACS5sSm45MgbuJrzttnPrpdulAuLiKxDni-6JcKzN5ZtM> ;
  nt:wasCreatedFromProvenanceTemplate <http://purl.org/np/RANwQa4ICWS5SOjw7gp99nBpXBasapwtZF1fIM3H2gYTM> ;
  nt:wasCreatedFromPubinfoTemplate <http://purl.org/np/RAA2MfgdBCzmz9yVWjKLXNbyfBNwMmOqcNUxkk1maIM> ,
<http://purl.org/np/RAOGu9Lh0BD4tbIRB9RG6RGRA_Obdh75NTbIqaWgxxs8M> ,
<http://purl.org/np/RAjpbMlw3owYhJUBo3DtsuDLXsNAJ8cnGeWAutDVjuAuI> ;
  nt:wasCreatedFromTemplate <http://purl.org/np/RADpgRpigXtt8iPV9uOPf3wIT3qzOI8Sg2Q72CNV8g-Yo> .
}

```

This is the class definition of “integrin clustering”:

```

@prefix this: <http://purl.org/np/RAF8AVn-wnTcSGxvPZ1Uiy_AtOhINlynnAxxiCdcTVWU> .
@prefix sub: <http://purl.org/np/RAF8AVn-wnTcSGxvPZ1Uiy_AtOhINlynnAxxiCdcTVWU#> .
@prefix np: <http://www.nanopub.org/nschema#> .
@prefix dct: <http://purl.org/dc/terms/> .
@prefix nt: <https://w3id.org/np/o/ntemplate/> .
@prefix npx: <http://purl.org/nanopub/x/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix orcid: <https://orcid.org/> .
@prefix prov: <http://www.w3.org/ns/prov#> .
@prefix skos: <http://www.w3.org/2004/02/skos/core#> .

sub:Head {
  this: np:hasAssertion sub:assertion ;
  np:hasProvenance sub:provenance ;
  np:hasPublicationInfo sub:pubinfo ;
  a np:Nanopublication .
}
sub:assertion {
  sub:integrin-clustering a <http://www.w3.org/2002/07/owl#Class> ;
  rdfs:label "integrin clustering" ;
  rdfs:subClassOf <http://www.wikidata.org/entity/Q14633861> ;
  skos:definition "clustering of integrin proteins at a focal adhesion" ;
  skos:relatedMatch <http://www.wikidata.org/entity/Q904514> .
}
sub:provenance {
  sub:assertion prov:wasAttributedTo orcid:0000-0002-0830-7029 .
}
sub:pubinfo {
  sub:sig npx:hasAlgorithm "RSA" ;
  npx:hasPublicKey

```

```

"MIGfMA0GCSqGSIb3DQEBAQUAA4GNADCBiQKBgQCluZ2msgo7OqPkyRoZM1uzpaLX8KRHyDe3J/cZwm6+Vq/CKVIGsGaT7/XH435cE9J8dwCgQ/Jssjlj6oqX+nSI9x
XBtMH9ZeyGHFBzKlcUBy/rRSez4EnwbSlsKMBS4MBCXQ9R3jZ3GpsN0GmIrS1ukKkUBQrREBYpb4w5MbGywIDAQAB" ;
  npx:hasSignature
"Bw052zD4Sg8+EkXb26m8oz03UEYZVfzKsvkEbf3j/zJeQJ/2PsYF94kN6QBs0mKoSeHJJQxOMOer6WCcTbYmltVlG2zQYEFc3wkhRMTx5eEVjEMAXx4S57/Ur2a5y
h+HzyqELJ1jG+2JIUQdHKO8F0F0VUqB2tyEf/ZhjMFz10=" ;
  npx:hasSignatureTarget this: .
  this: dct:created "2021-11-12T09:17:34.478-08:00"^^xsd:dateTime ;
  dct:creator orcid:0000-0002-0830-7029 ;
  npx:introduces sub:integrin-clustering ;
  npx:supersedes <http://purl.org/np/RA9UaQM3wVa9xRAmL9CWEXyhDbcgvH1PoGTw4pnKaHYL8> ;
  <https://w3id.org/linkflows/reviews/isUpdateOf> <http://purl.org/np/RA9UaQM3wVa9xRAmL9CWEXyhDbcgvH1PoGTw4pnKaHYL8> ;
  nt:wasCreatedFromProvenanceTemplate <http://purl.org/np/RANwQa4ICWS5SOjw7gp99nBpXBasapwtZFIIM3H2gYTM> ;
  nt:wasCreatedFromPubinfoTemplate <http://purl.org/np/RAA2MfgdBCzmz9yVWjKLNbyfBNcwsMmOqcNUxkk1maIM> ,
<http://purl.org/np/RAOGu9Lh0BD4tbIRB9RG6RGRA_ObDh75NTbIqaWgxxs8M> ,
<http://purl.org/np/RAjpbMlw3owYhJUBo3DtsuDLXsNAJ8cnGeWAutDVjuAuI> ;
  nt:wasCreatedFromTemplate <http://purl.org/np/RAqpgRpigXtt8iPV9uOPf3wIT3qzOI8Sg2Q72CNV8g-Yo> .
}

```

References

- [1] C.I. Bucur, T. Kuhn, D. Ceolin and J. van Ossenbruggen, Expressing high-level scientific claims with formal semantics, in: *Proceedings of the 11th Knowledge Capture Conference*, 2021. doi:[10.1145/3460210.3493561](https://doi.org/10.1145/3460210.3493561).
- [2] M. Paszek, C. DuFort, O. Rossier et al., The cancer glycolyx mechanically primes integrin-mediated growth and survival, *Nature* **511** (2014), 319–325. doi:[10.1038/nature13535](https://doi.org/10.1038/nature13535).