

ON CORONA LIMIT OF TILINGS AND CRYSTAL GROWTH

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ヒューゴー賞/ネビュラ賞受賞!

楽園の泉

アーサー・C・クラーク/山高 昭訳



THE FOUNTAINS OF PARADIS

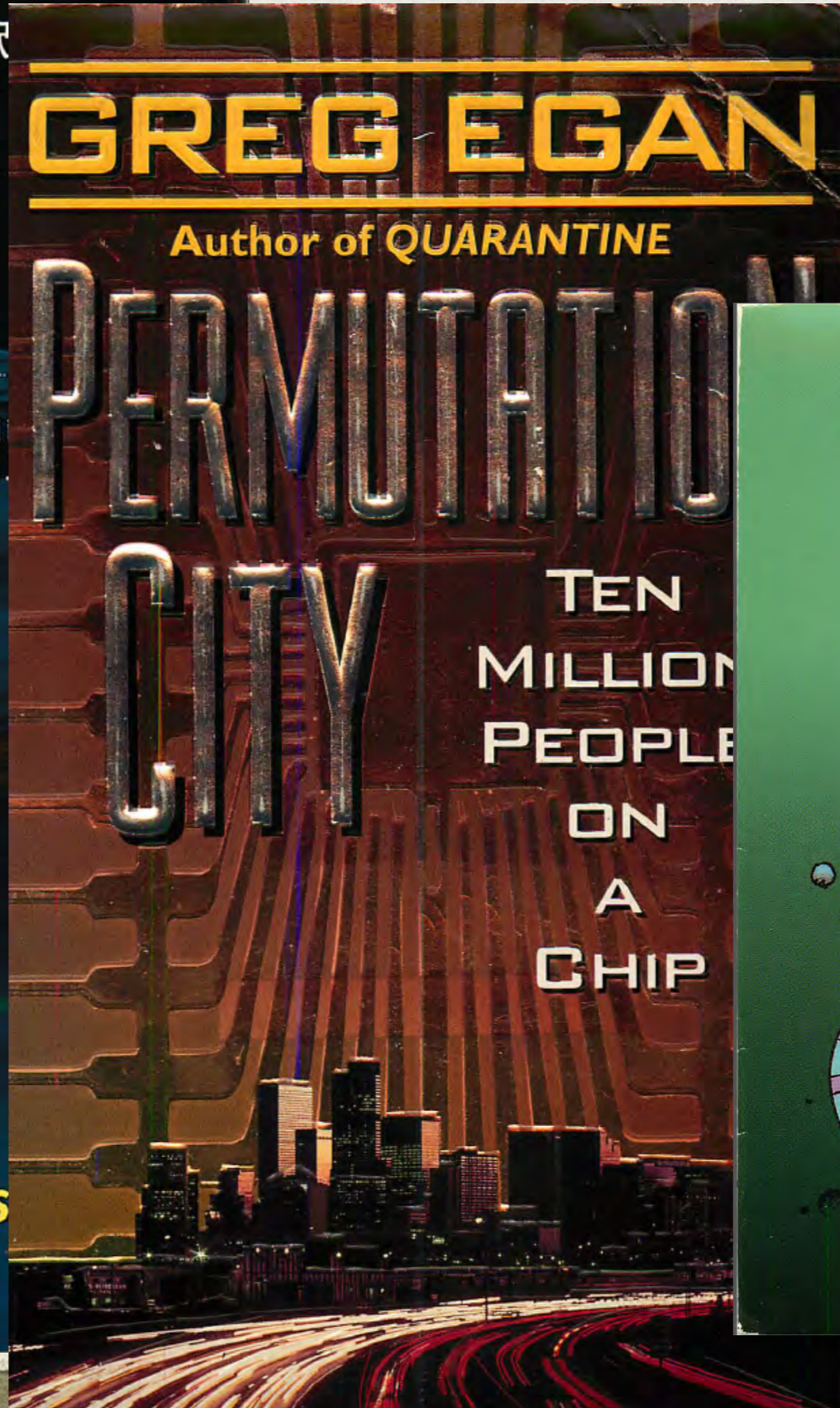
Do you read Science Fiction novels?

GREG EGAN

Author of QUARANTINE

PERMUTATION
CITY

TEN
MILLION
PEOPLE
ON
A
CHIP



WHITE LIGHT

ホワイト・ライト

ルーティ・ラッカー/黒丸尚訳



Why I had been reading Sci-Fi novels?

To feel a kind of **sense of wonder**.

I am a "sense of wonder" addict.

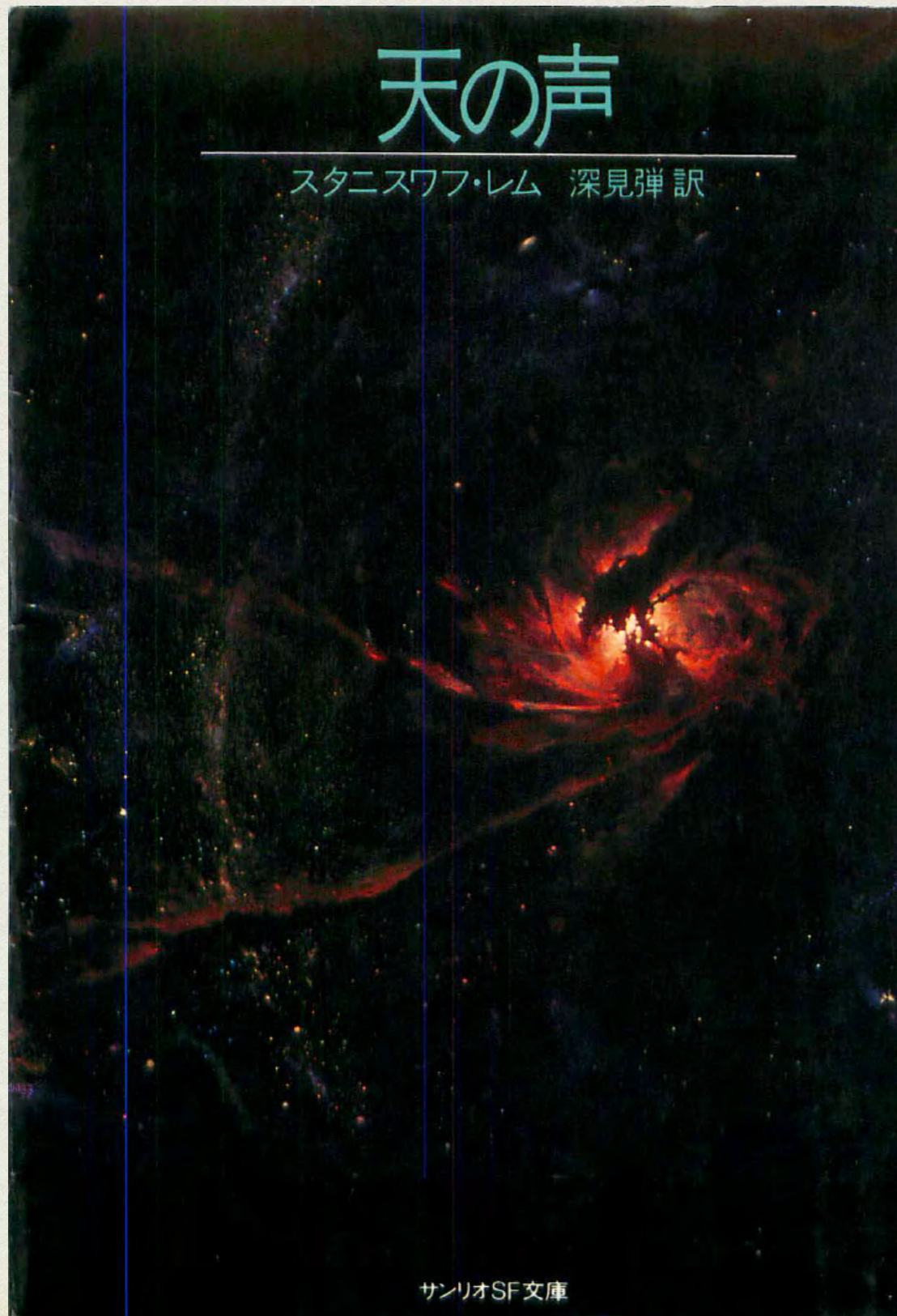
Definition of 'sense of wonder'

Wikipedia:

センス・オブ・ワンダーとは、一定の対象（SF作品、自然等）に触れることで受ける、ある種の不思議な感動、または不思議な心理的感覚を表現する概念であり、それを言い表すための言葉である。

A sense of wonder is an intellectual and emotional state most frequently invoked in discussions of science fiction.

His Master's Voice (Głos Pana)
Stanisław Lem



「レムの『天の声』は情報科学の
本質をよく表していますね」

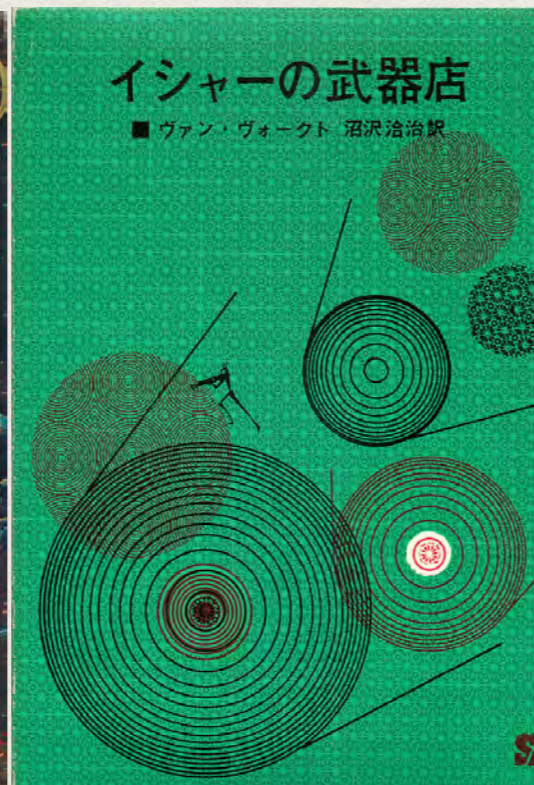
小林孝次郎

Wide-screen Baroque

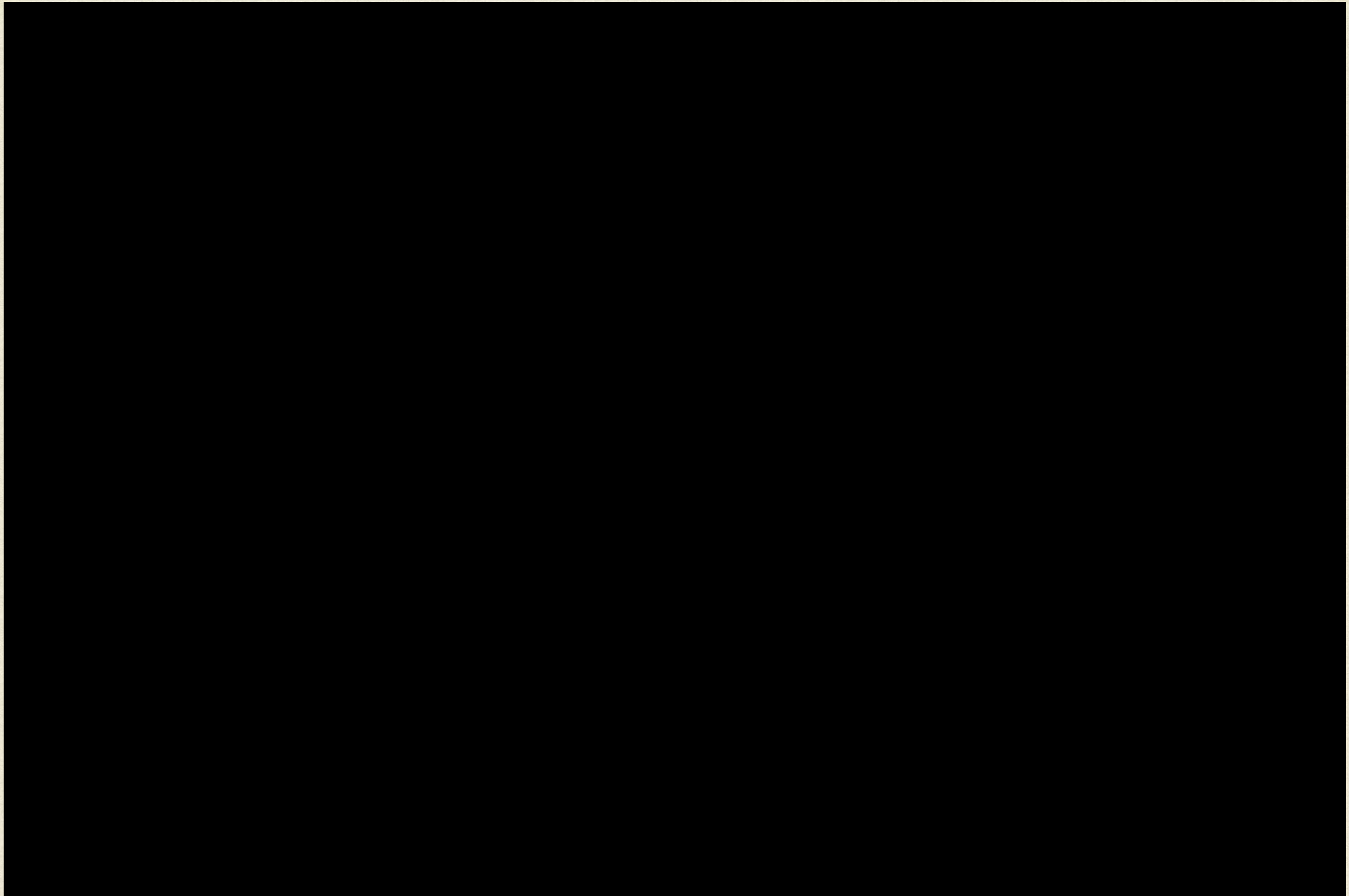
A **very** small subclass of science fiction novels.
For a reader who want to take a shower of sense of wonder.

A subgenre of science fiction characterized by larger-than-life characters, violence, intrigue, extravagant settings or actions, and fast-paced plotting.

Brian Wilson Aldiss



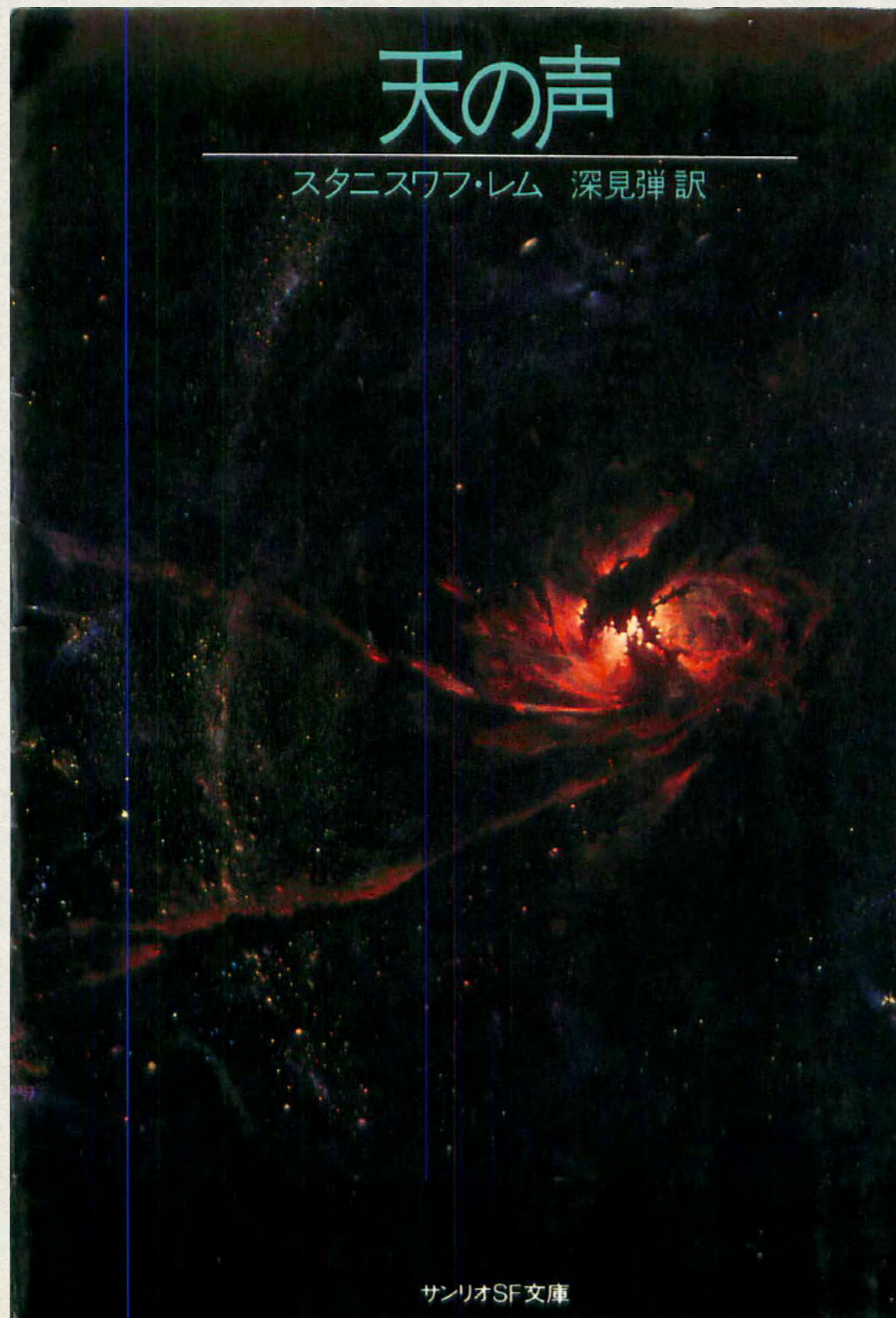
Of course, the notion of 'sense of wonder'
is not only for Sci-fi or nature.



<https://www.youtube.com/watch?v=7Mb47wovBo4>

Even the case of pure literatures, we can discuss about there sense of wonder.

His Master's Voice (Głos Pana)
Stanisław Lem



The Key
Jun'ichirō Tanizaki



When I was a high school student, I was interested in micro/personal computers.

Why I felt a sense of wonder in personal computing?

マイ・コンピュータ 入門

コンピュータはあなたにもつくれる

安田 寿明



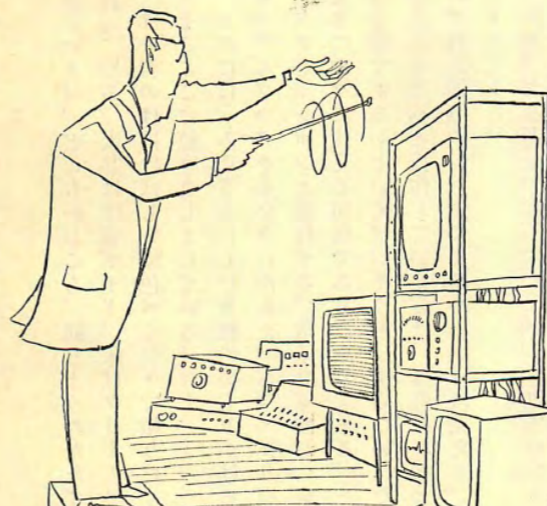
BLUE BACKS



1-2 NECのコンピュータ組み立てキット

第六章

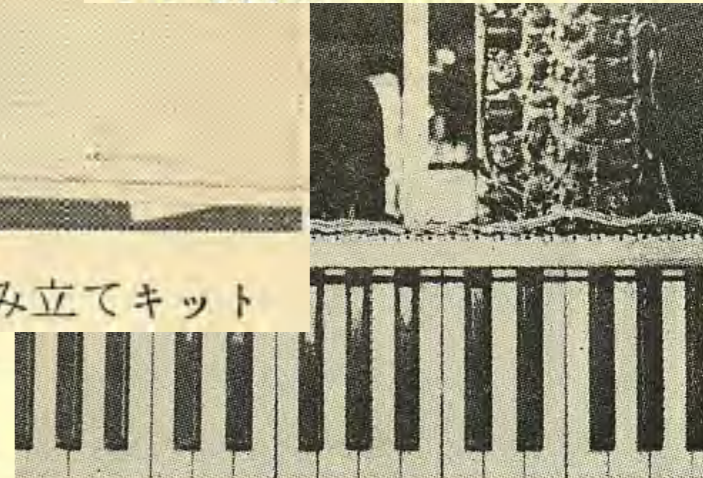
テクノ・クラフト・アートの時代



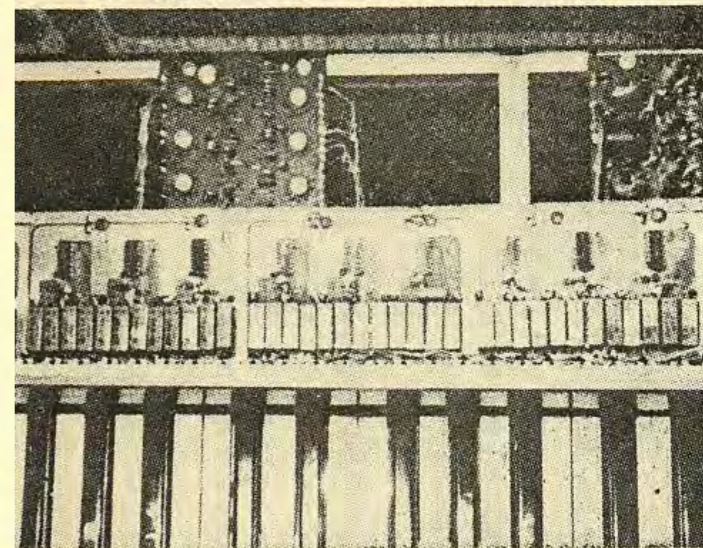
第一章 “神”ではなくなったコンピュータ



1-1 東京秋葉原に開店したコンピュータ・半導体店



4-2 改造前のエレクトーン内部の鍵盤スイッチ部



4-3 改造したエレクトーン内部。リード・リレーをびっしり並べてある

But I chose a department of
biophysical engineering.

Why I gave up entering a department
of information engineering and choose
that of bio-physical engineering?

Because I saw this machine at Fuji-Xerox Osaka showroom...

Almost everything I could imagine was there and it had already been sold as it is.

Xerox Star workstation 1981~

\$16,000~



富士ゼロックス8012-J スター インフォメーション システム

The 'next'
must be...

Is my thinking process
printable to a storage?

Is it possible to download
my consciousness?

Yes, I was actually
serious at the time :-)

eg. Minsky believed so,
but Penrose does not.



ノーバート・ウィーナー

サイバネティクス 第2版

動物と機械における制御と通信

池原止戈夫・彌永昌吉 共訳
室賀三郎・戸田 巖

岩波書店

The department was
founded by whom felt
a sense of wonder in
this book.

Norbert Wiener, *Cybernetics:
Or the Control and
Communication in the Animal
and the Machine.* (1948)

cf. cyber-something

No one in the department knew exactly what cybernetics is.

No one in the department knew what tool is most effective
for studying cybernetics.

Far from 'Liberal Arts,'
or rather unprincipled.

But it was tooo unprincipled, as the result, the set of lectures might close to that of liberal arts...

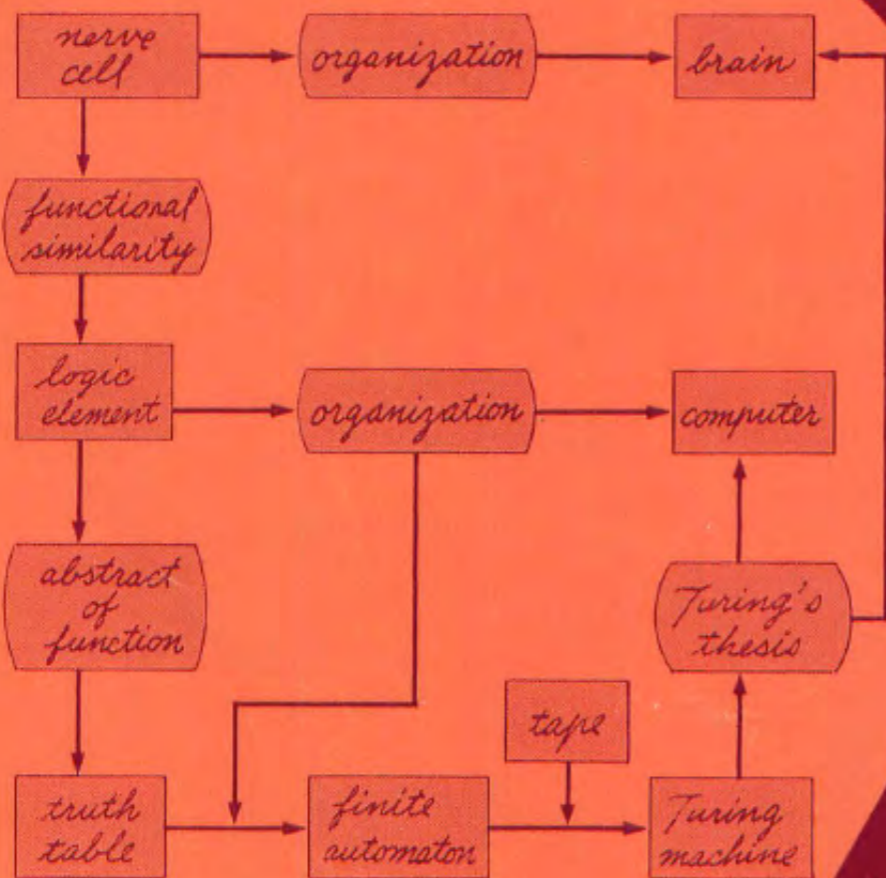
But there was a full of sense of wonder...

※個人の感想です

生物物理学序説

— 神経膜の興奮, 思考の基礎論 —

三井利夫・菅田一博・広野 力・中西健二/著



共立出版株式会社

Introduction to Bio-physics

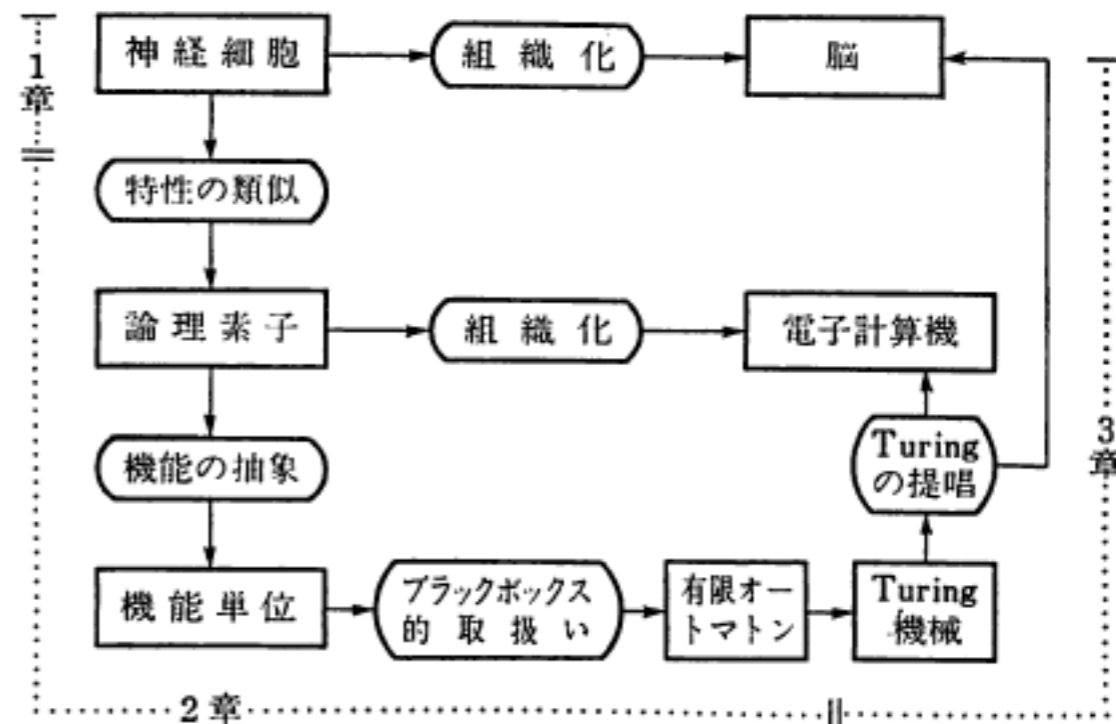
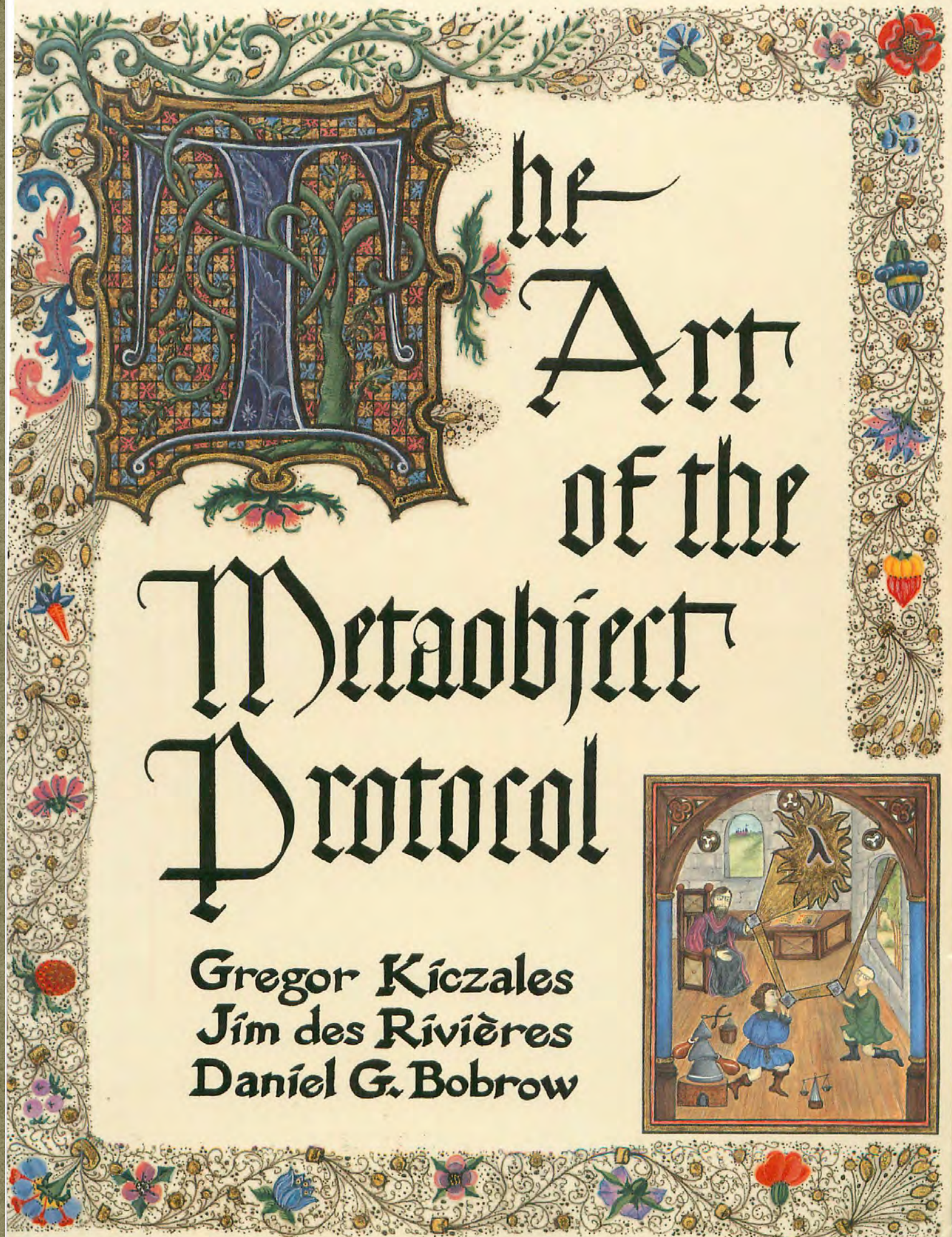


図 0.1 本書の論述の進め方
点線で示した下まわりの道をたどる。

1. Excitation of nerve membrane
2. Digital information processing
3. Theory of Turing



The
Art
of the
Metaobject
Protocol

Gregor Kiczales
Jim des Rivières
Daniel G. Bobrow



about the object
system of any
object system.

Let's imagine an object
oriented language.

The class of 1,2,3... is
INTEGER class.

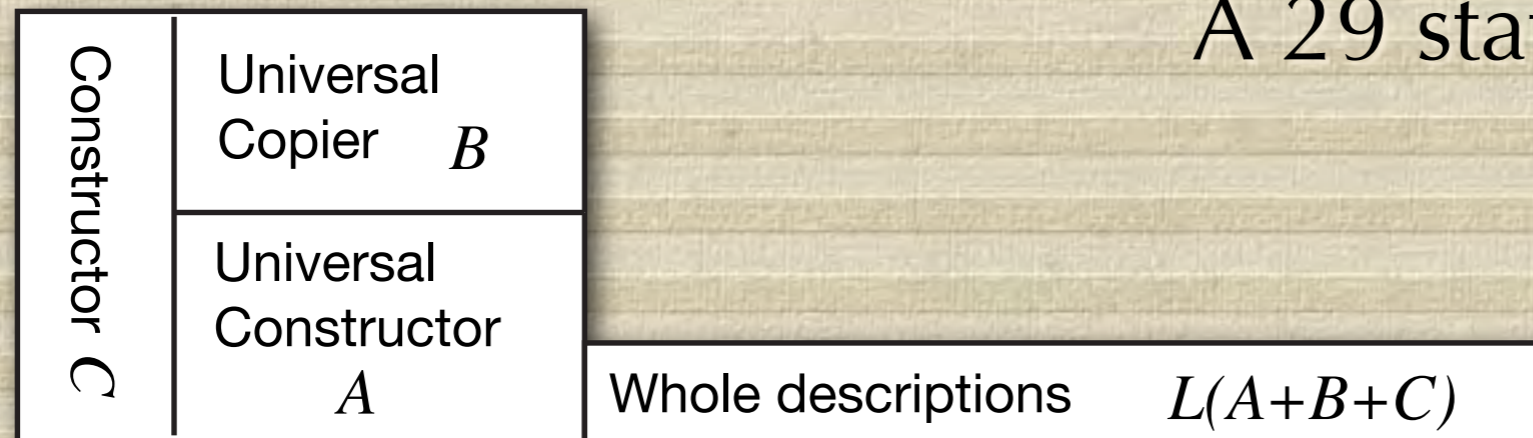
Then what is the class
of INTEGER class?

self-reference,
reflective system

This was an
implementation and
actually worked.

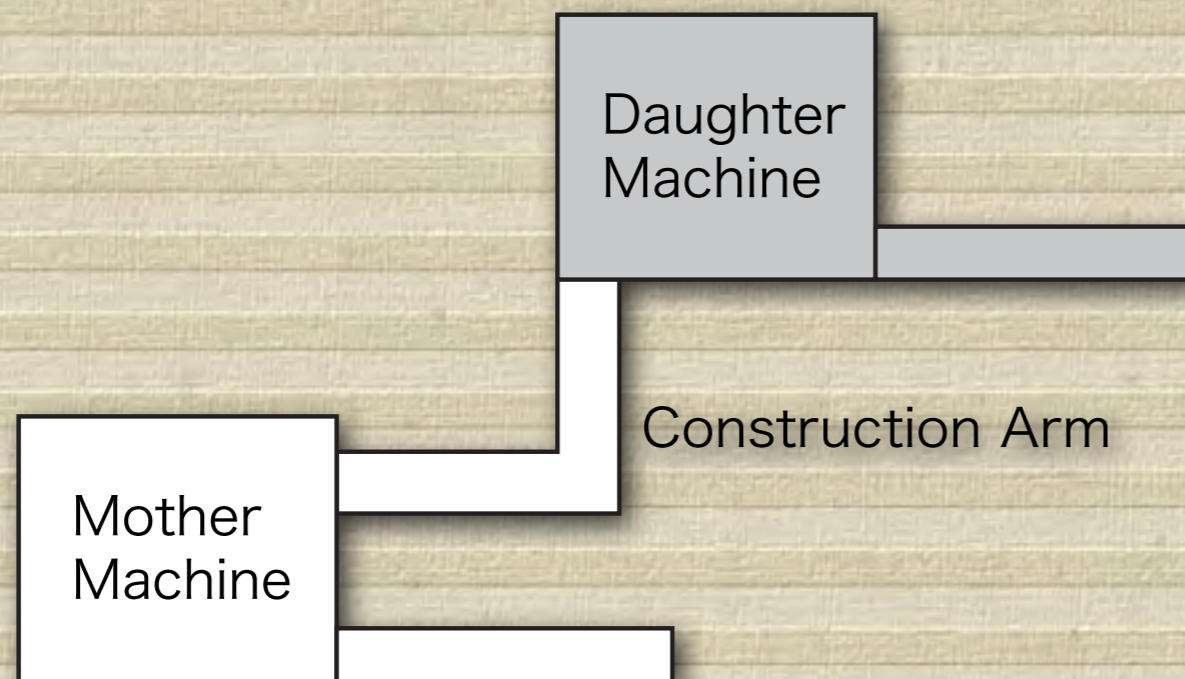
One of the origin of this type of **implementation** must be:

A self-reproducing digital structure by von Neumann



A 29 state cellular automaton
von Neumann 1950-

(cf. Watson, Crick 1953)



Computation and
construction universal

von Neumann (Burks ed.) 1966

Natural Computing

NCC

ナチュラルコンピューティング・シリーズ

萩谷昌己・横森 貴 編

第5巻

可逆計算

森田憲一 著

近代科学社「保護コンテンツ」

Any computing process
can be simulated by
reversible non-
dissipating system.

Theoretically,
reversible computing
process can be executed
with no energy.

I thought there is a
gateway to escape from
energy consumption, if
my thinking process
can be printable.

The best way to gain the opportunity
of invoking a sense of wonder is:

Just attend interesting lectures and
read interesting books!

But I was employed in a university and
have to create something :-)

How to create a thing invoking a new
sense of wonder by yourself?

I have no idea...



A thing which was believed to be impossible
turns out to be possible.

A thing which was believed to be trivially
possible turns out to be impossible.

They might invoke a sense of wonder...

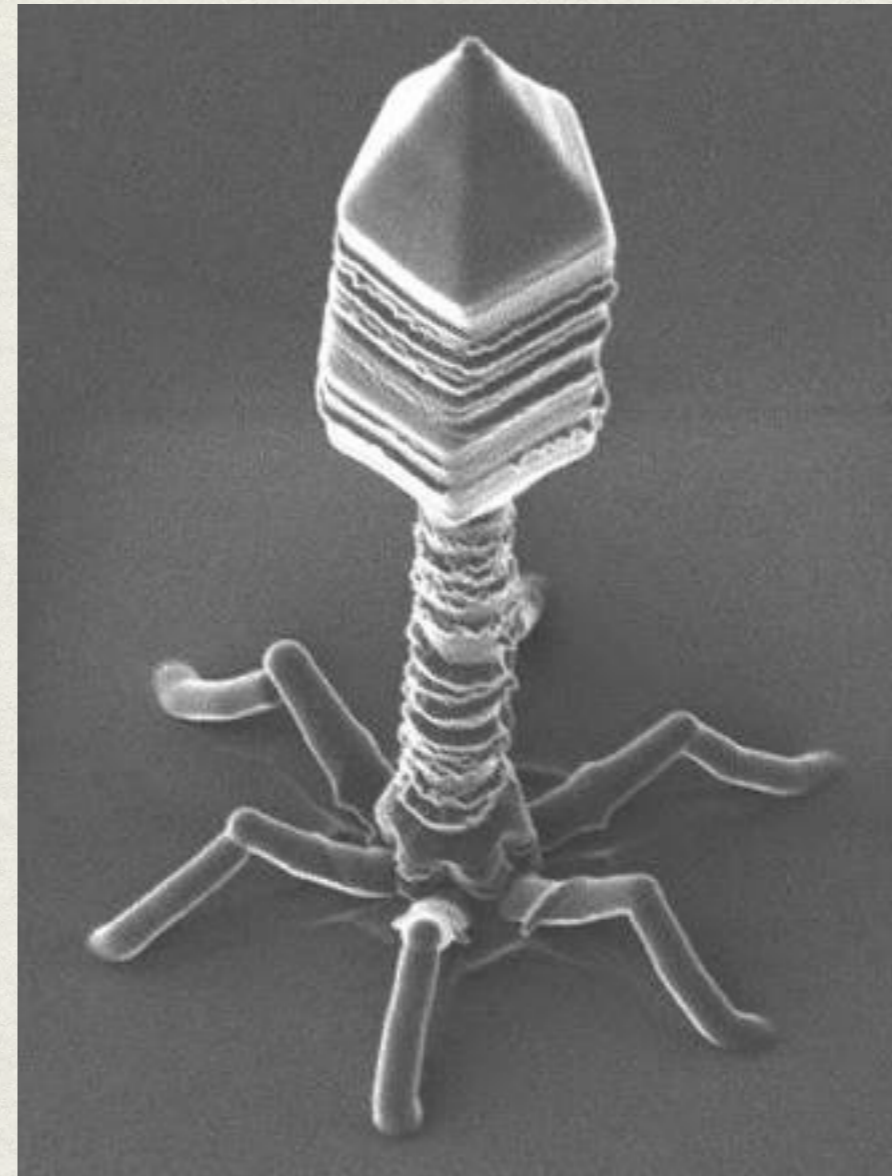
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turns out to be possible.

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possible turns out to be impossible.

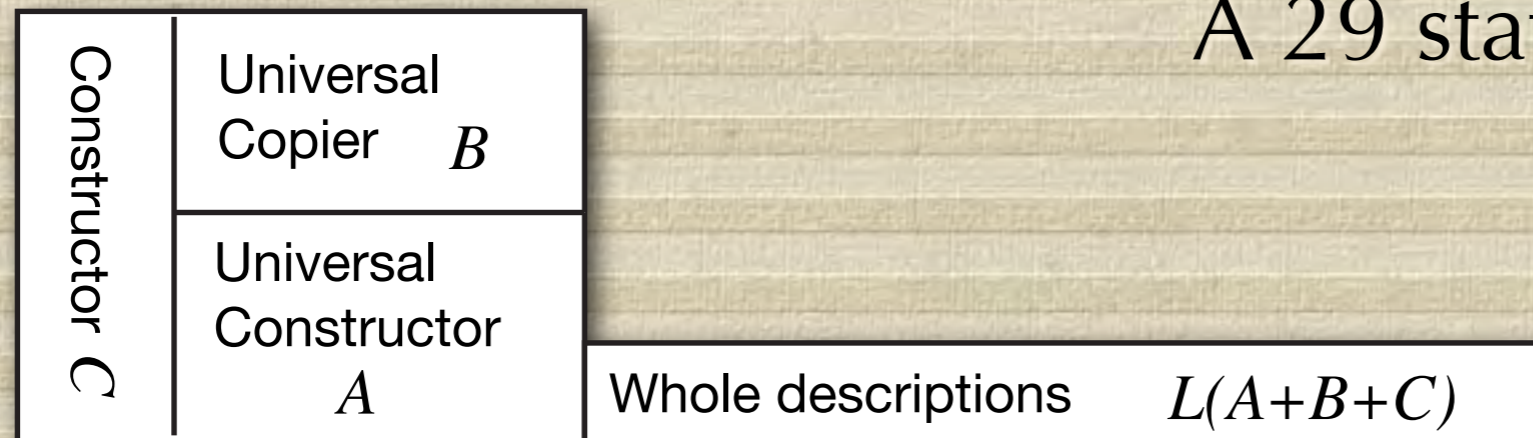
Usually it is difficult to show.

They might invoke a sense of wonder...

SELF-REPRODUCTION V.S. CRYSTAL GROWTH

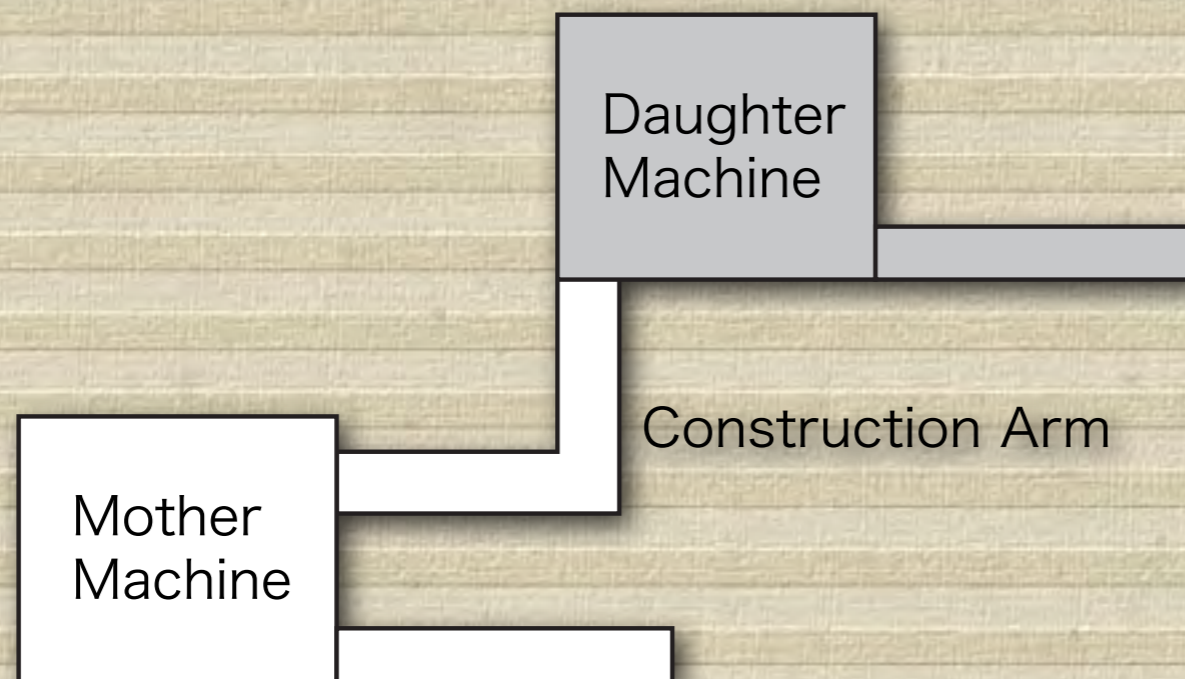


A self-reproducing digital structure by von Neumann



A 29 state cellular automaton
von Neumann 1950-

(cf. Watson, Crick 1953)



Computation and
construction universal

von Neumann (Burks ed.) 1966

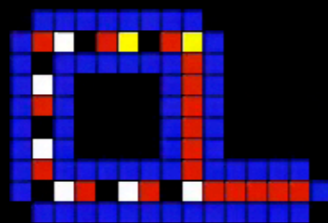
LANGTON'S SELF-REPRODUCING MODEL

An 8-state cellular automaton

“genetic information... interpreted and uninterpreted

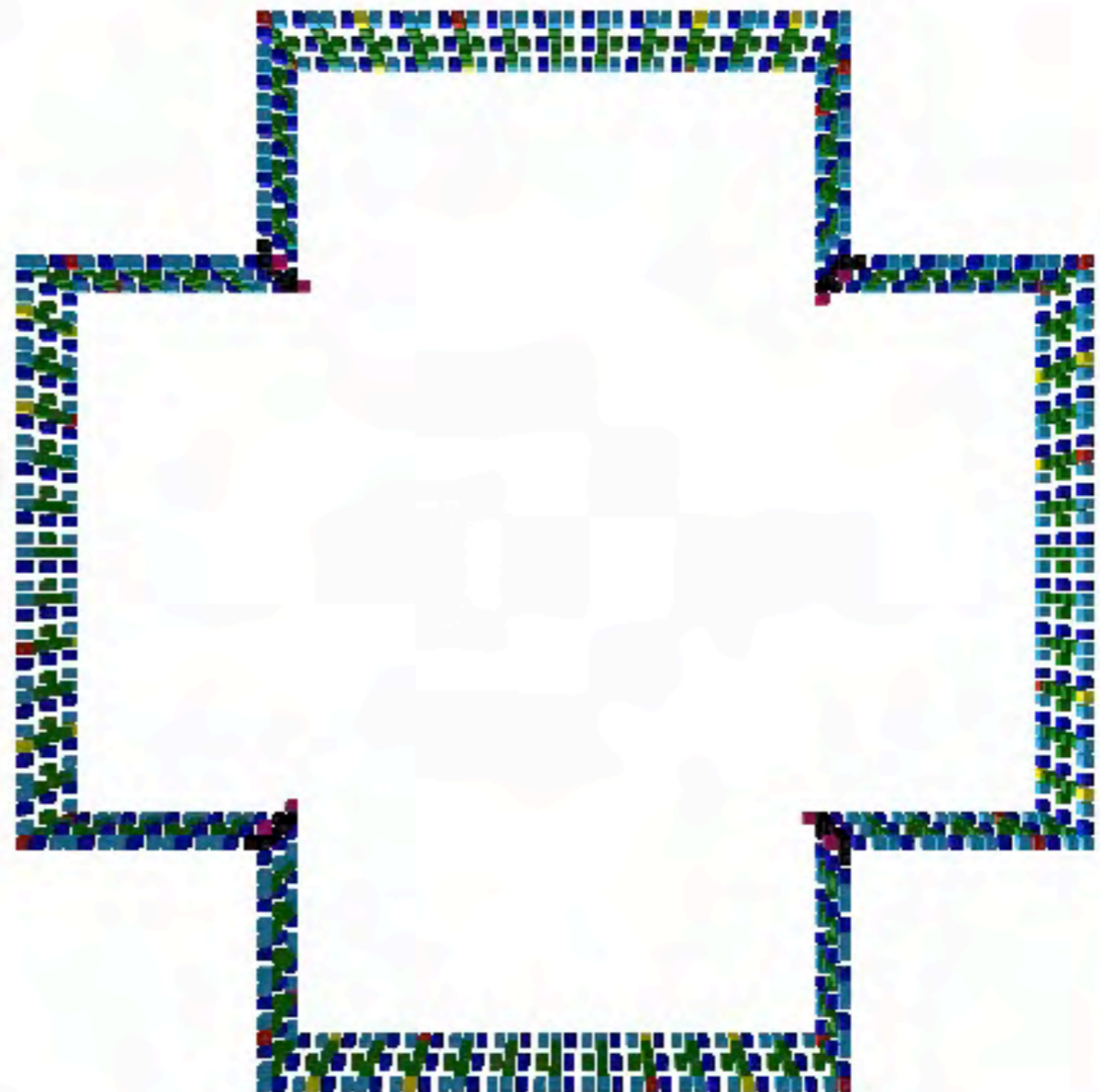
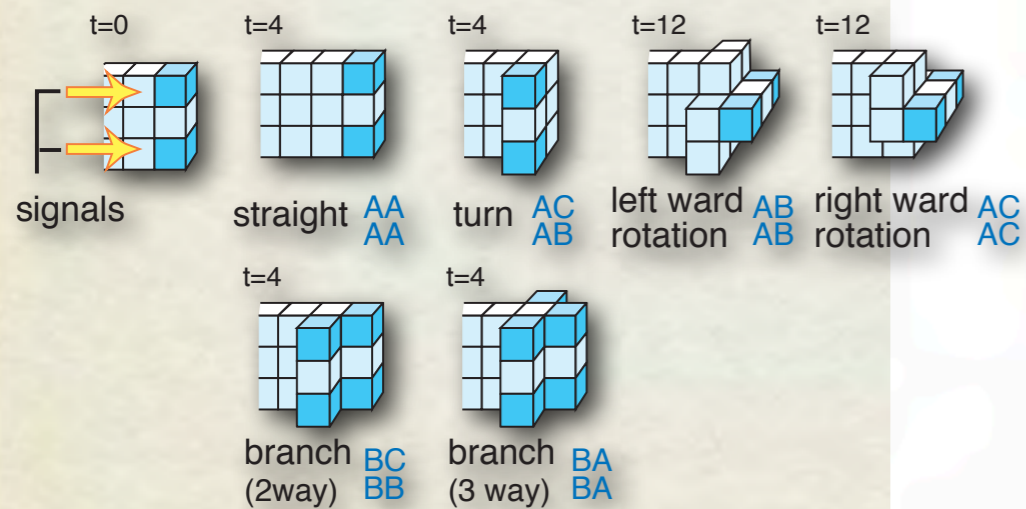
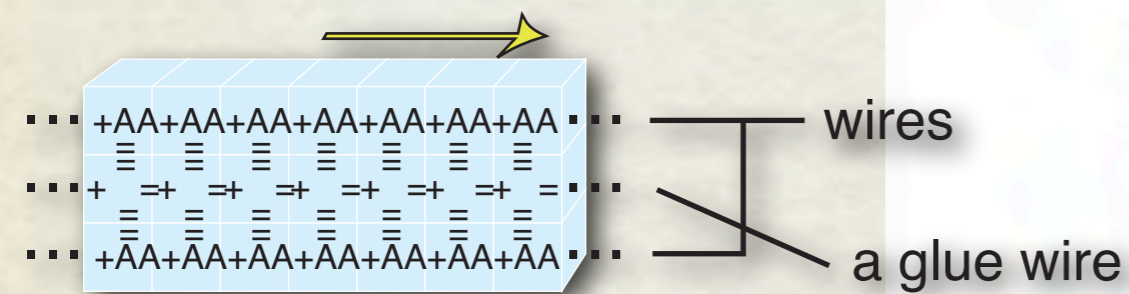
Langton 1984

The condition of computation and construction universality is too excess for the model of biological self-reproduction.



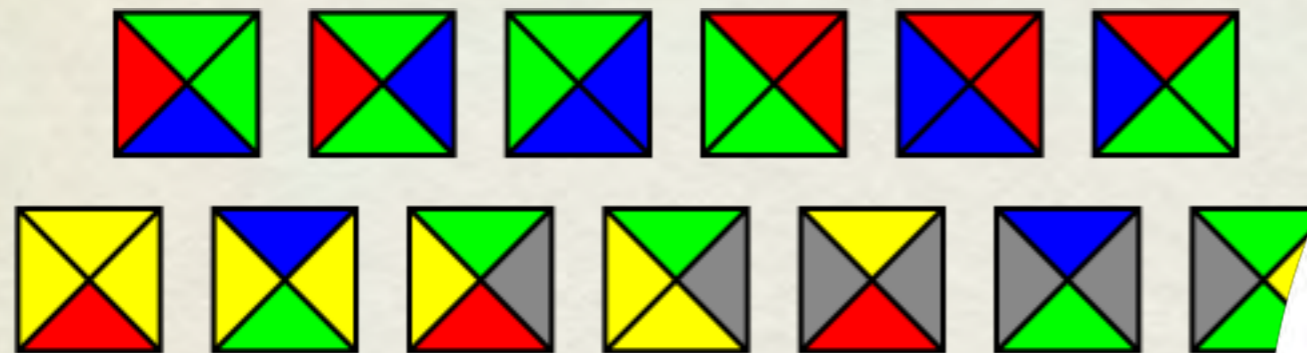
A REVERSIBLE LOOP

- A reversible non-dissipating artificial life model

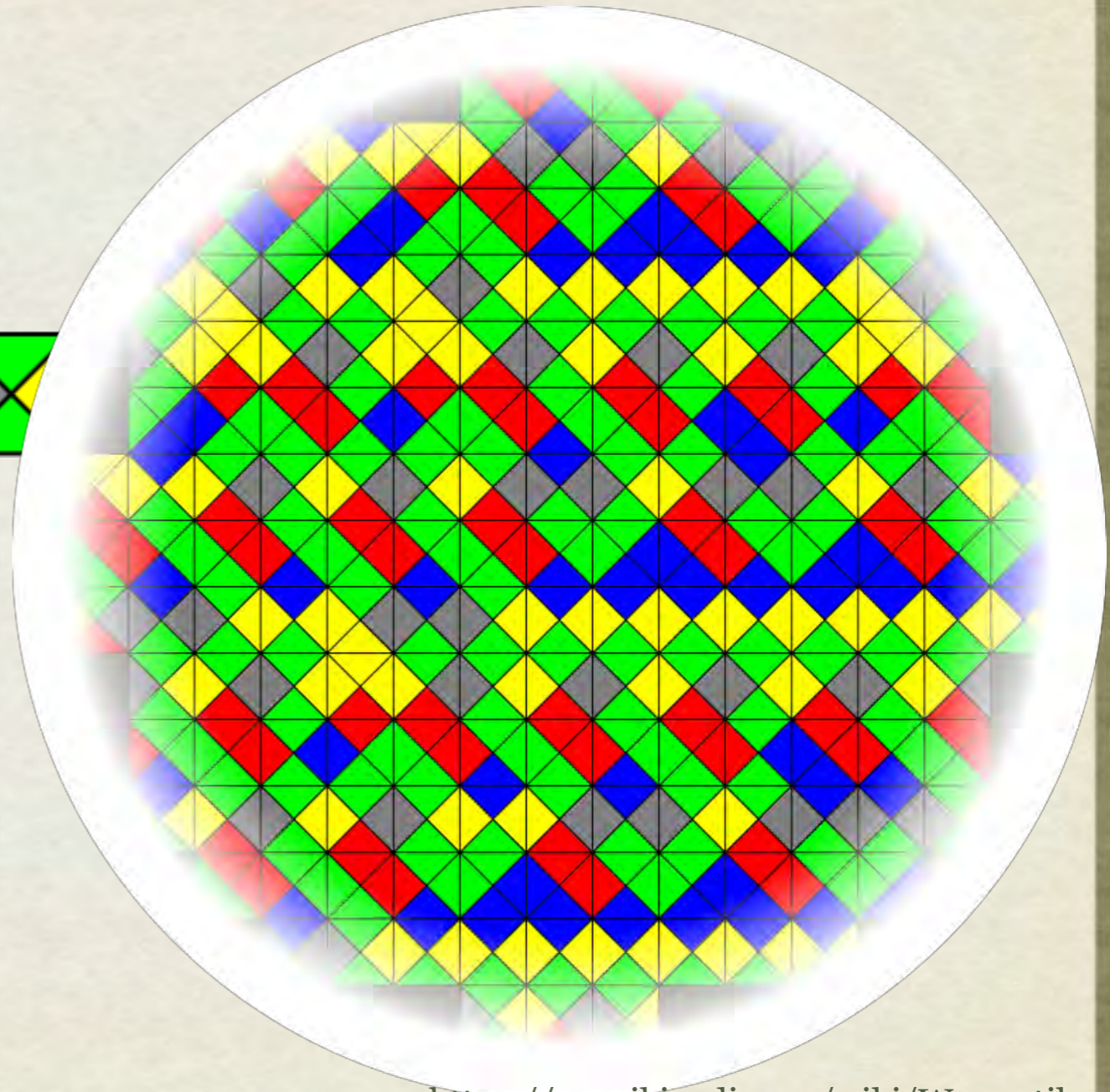


CRYSTAL GROWTH IS TRIVIAL?

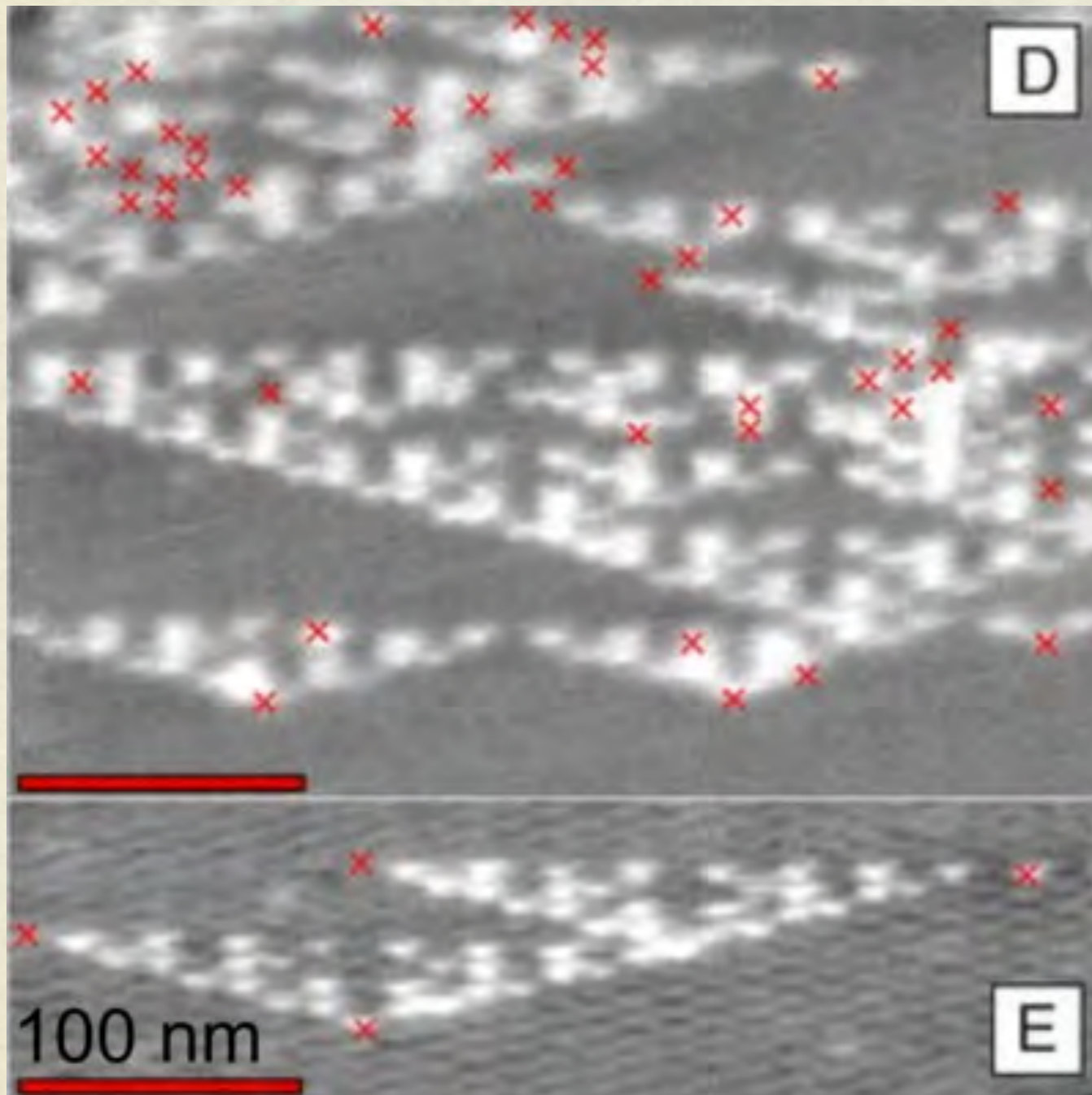
Wang's tiles



The process of tiling by a wang tile set can simulate any computing process.



COMPUTATION BY DNA TILES



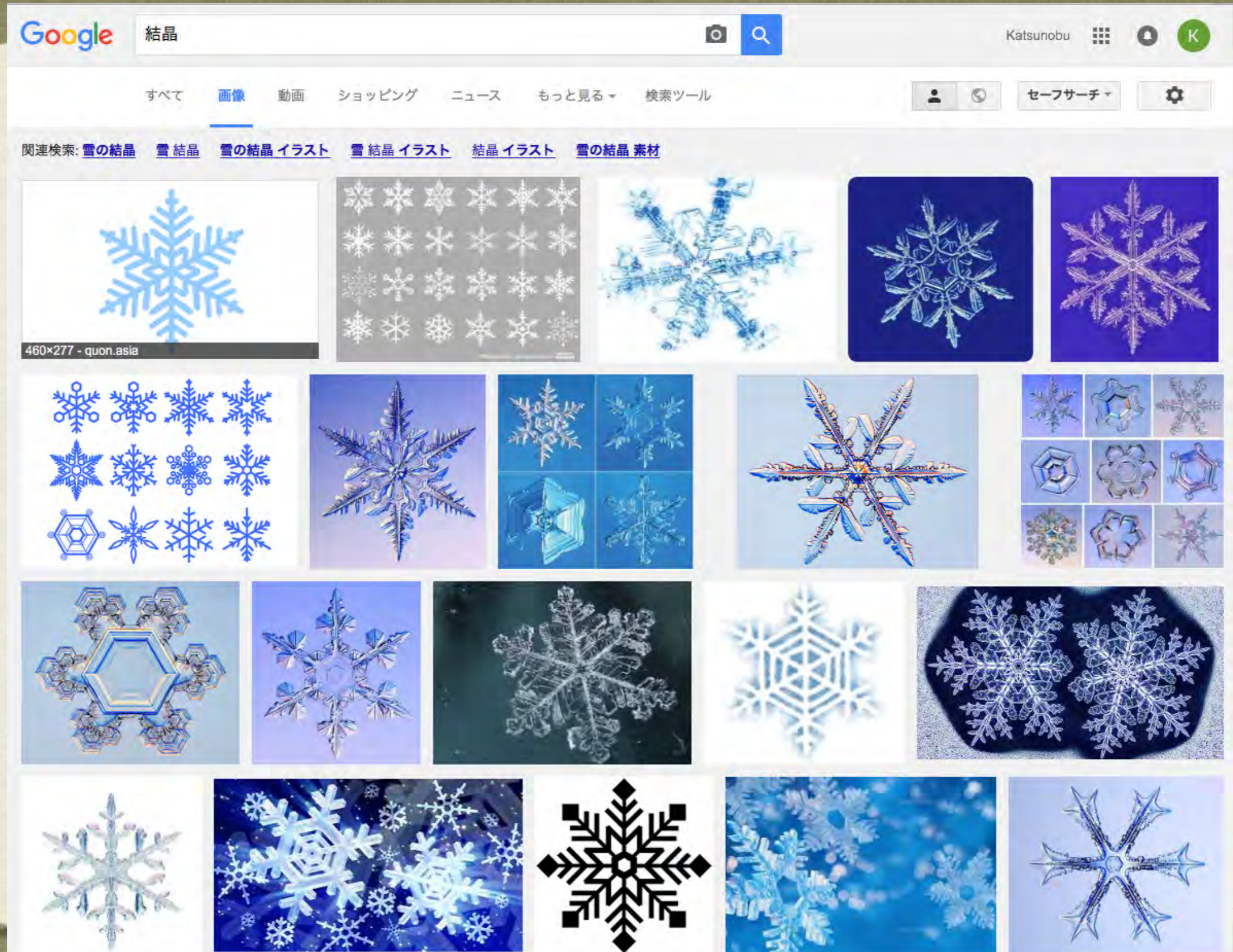
Winfree 1998

Algorithmic self-assembly of
DNA Sierpinski triangles

Rothemund et al, 2004

Seems to be too
complex for a
crystal growth.

SNOW CRYSTAL



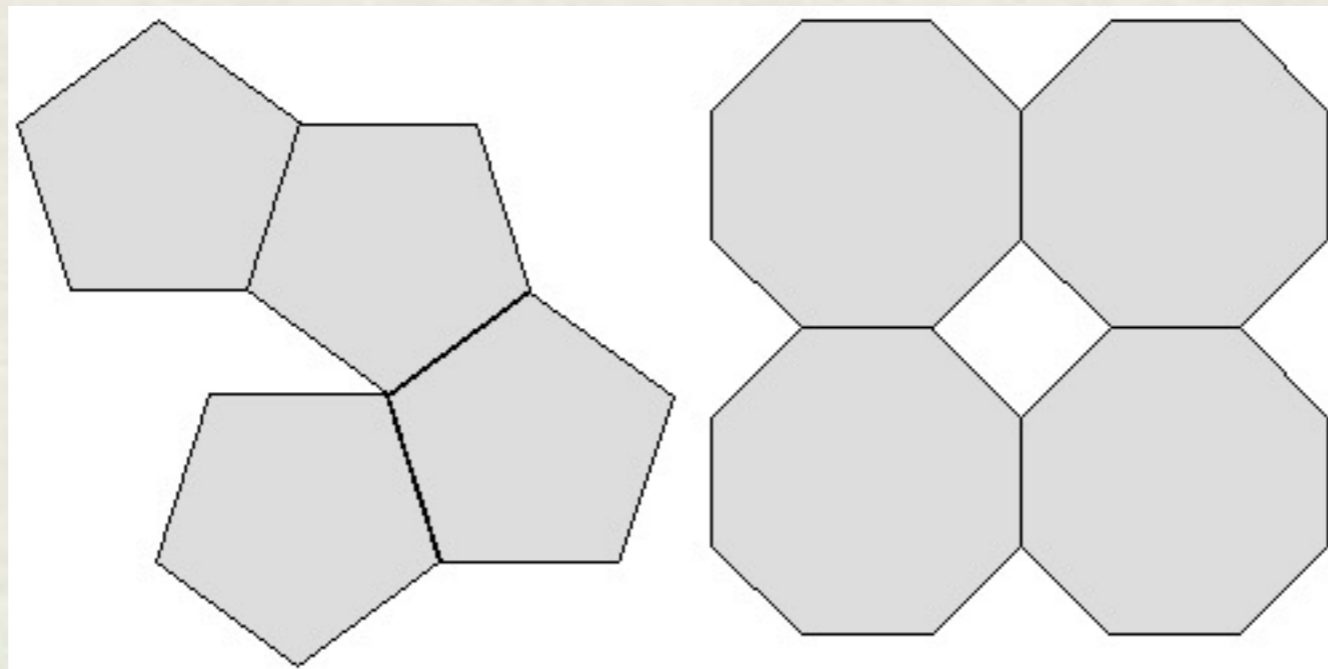
CRYSTALLOGRAPHIC RESTRICTION THEOREM

The crystallographic restriction theorem in its basic form was based on the observation that the rotational symmetries of a crystal are usually limited to 2-fold, 3-fold, 4-fold, and 6-fold.

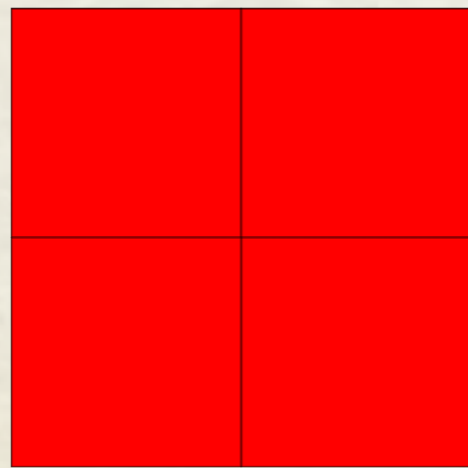
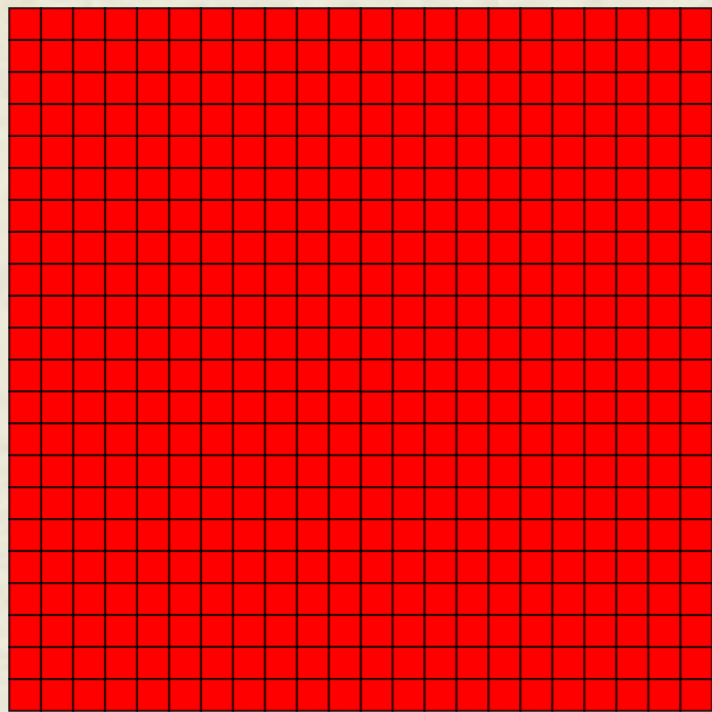
However, quasicrystals can occur with other diffraction pattern symmetries, such as 5-fold; these were not discovered until 1982 by Dan Shechtman.

CRYSTALLOGRAPHIC RESTRICTION THEOREM

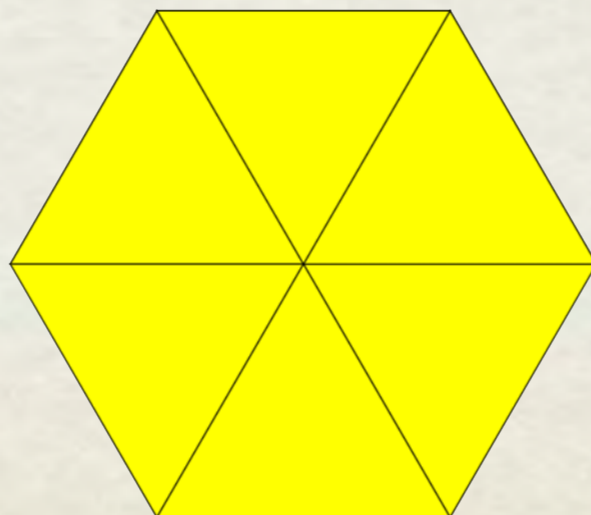
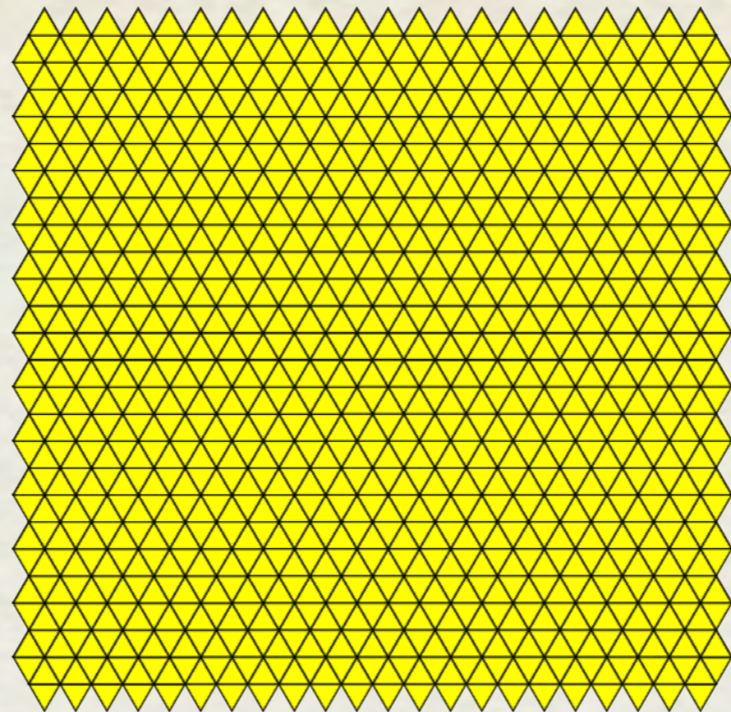
If we try to combine objects with 5-fold and 8-fold apparent symmetry, we cannot combine them in such a way that they completely fill space.



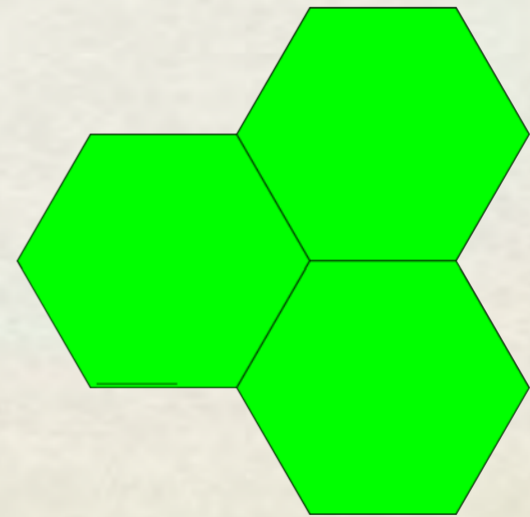
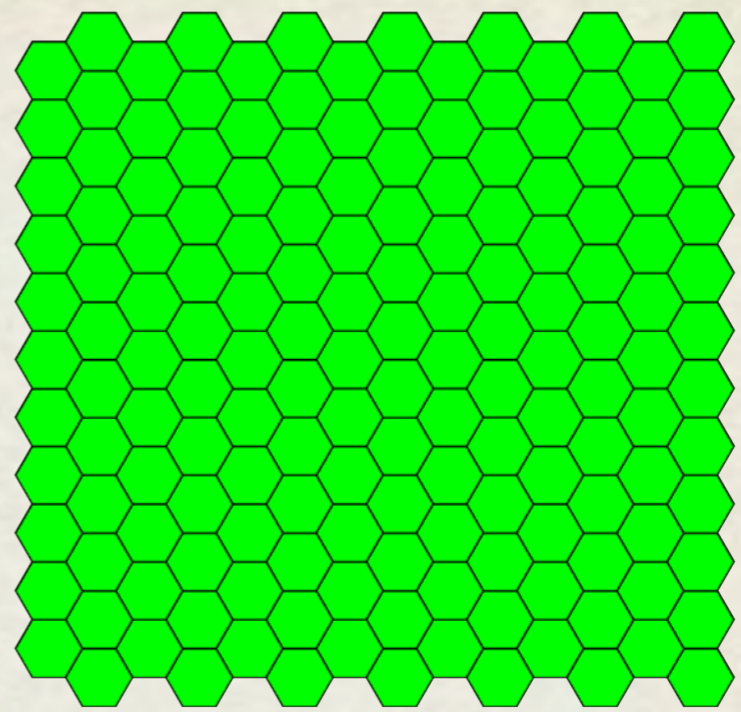
REGULAR TILINGS



4.4.4.4



3.3.3.3.3.3



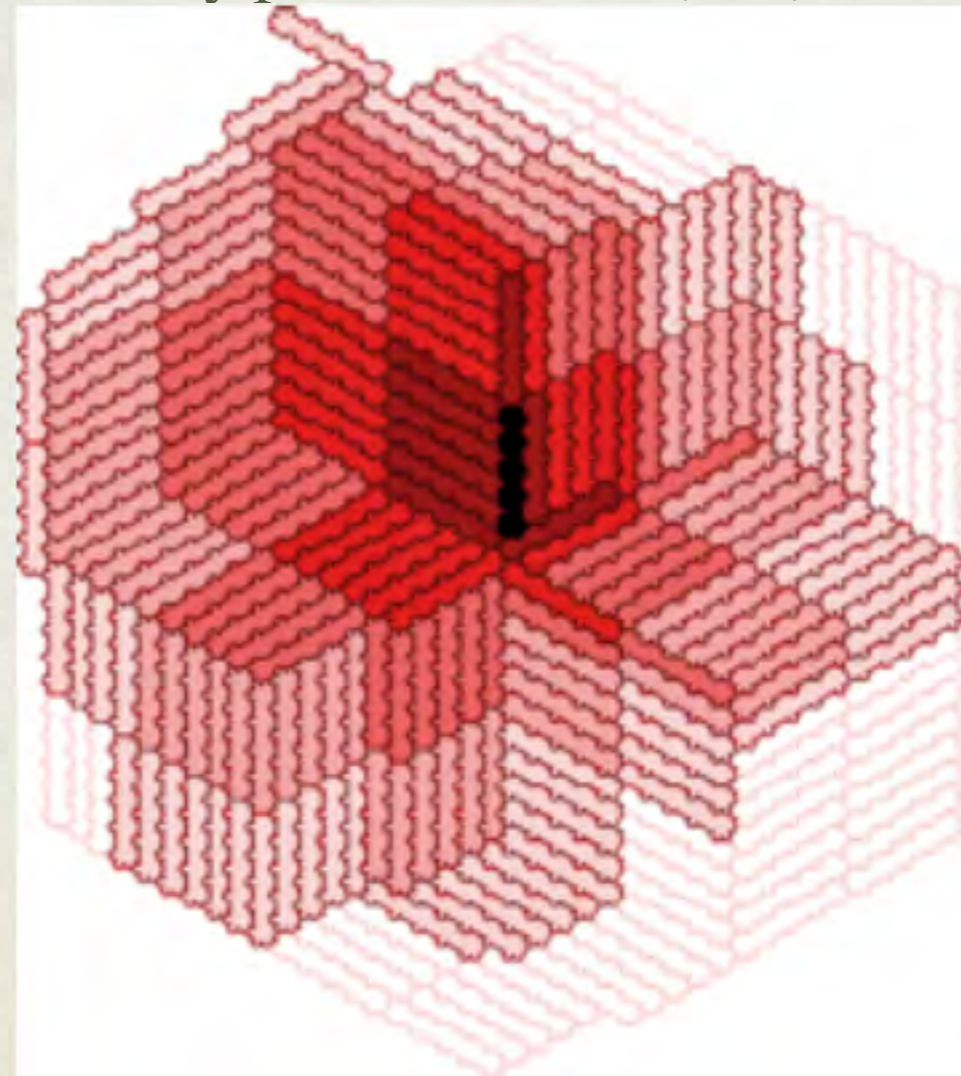
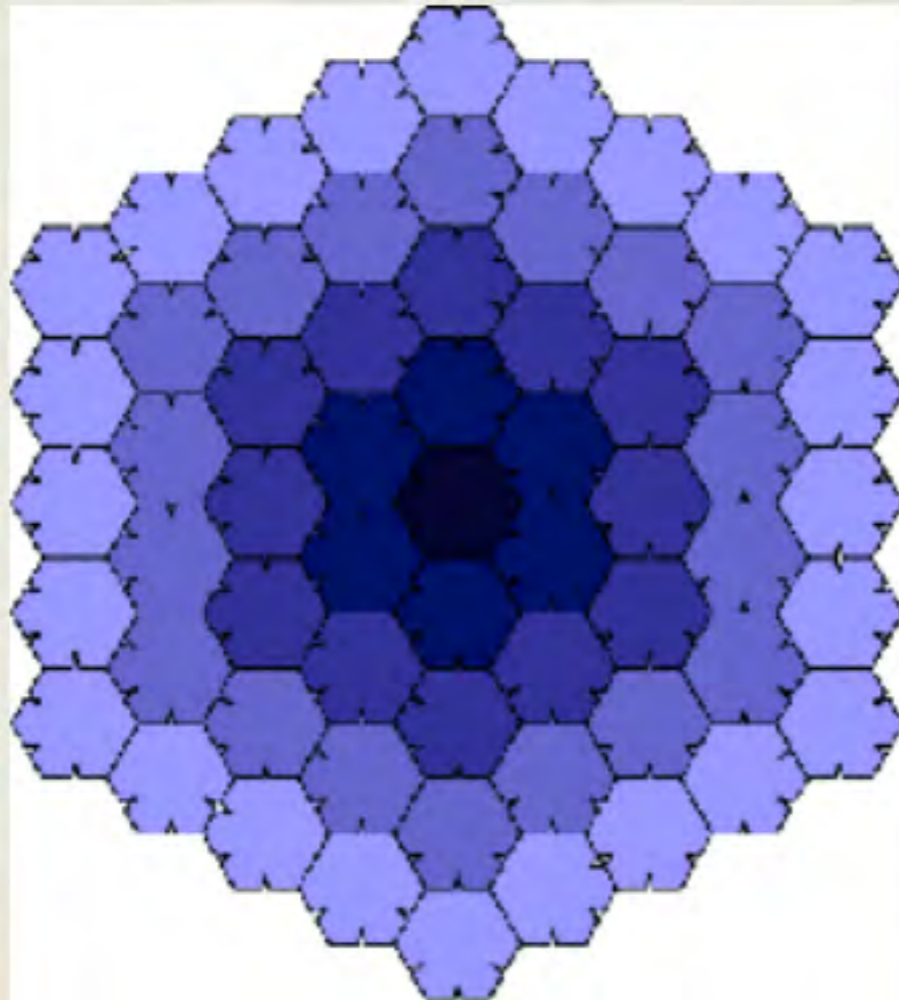
6.6.6

CORONA

A simple model of crystal growth.

The 0-th corona: a tile is defined as the tile itself

The k -th corona: the set of tiles sharing a boundary point with the $(k-1)$ -th corona

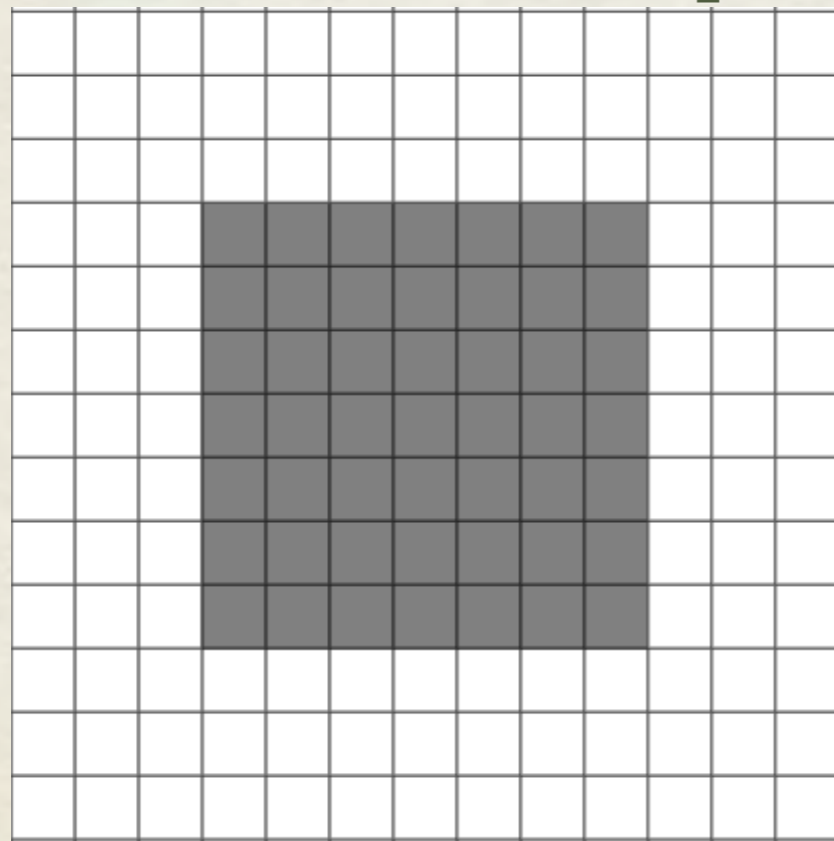


CORONA & EDGE CORONA

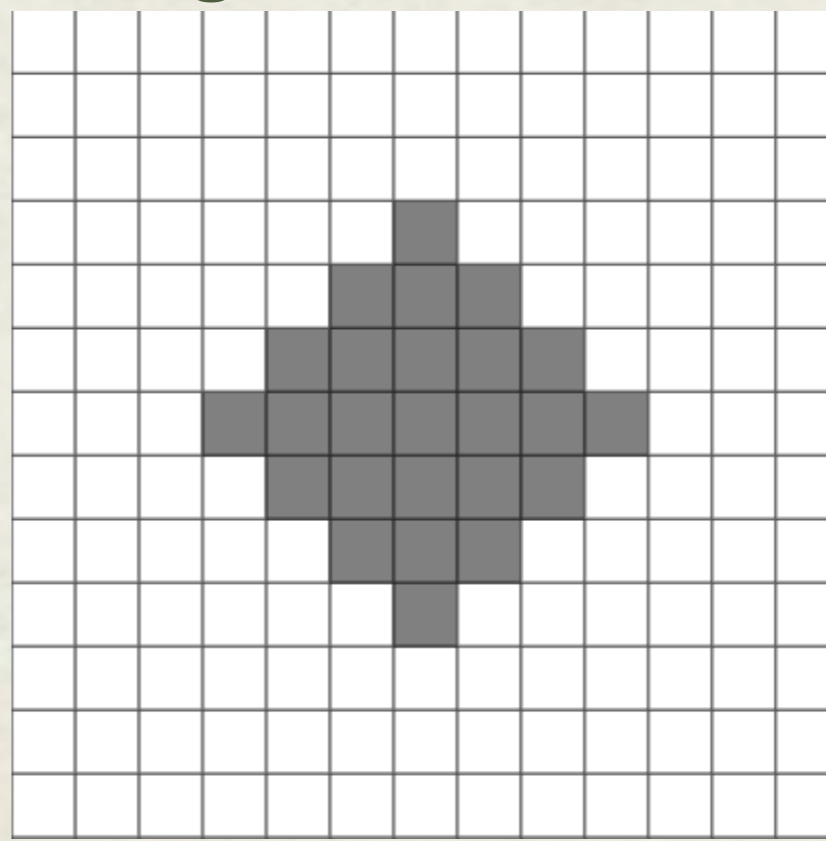
The 0-th corona: a tile is defined as the tile itself

The k-th corona: the set of tiles sharing a **edge** with the (k-1)-th corona

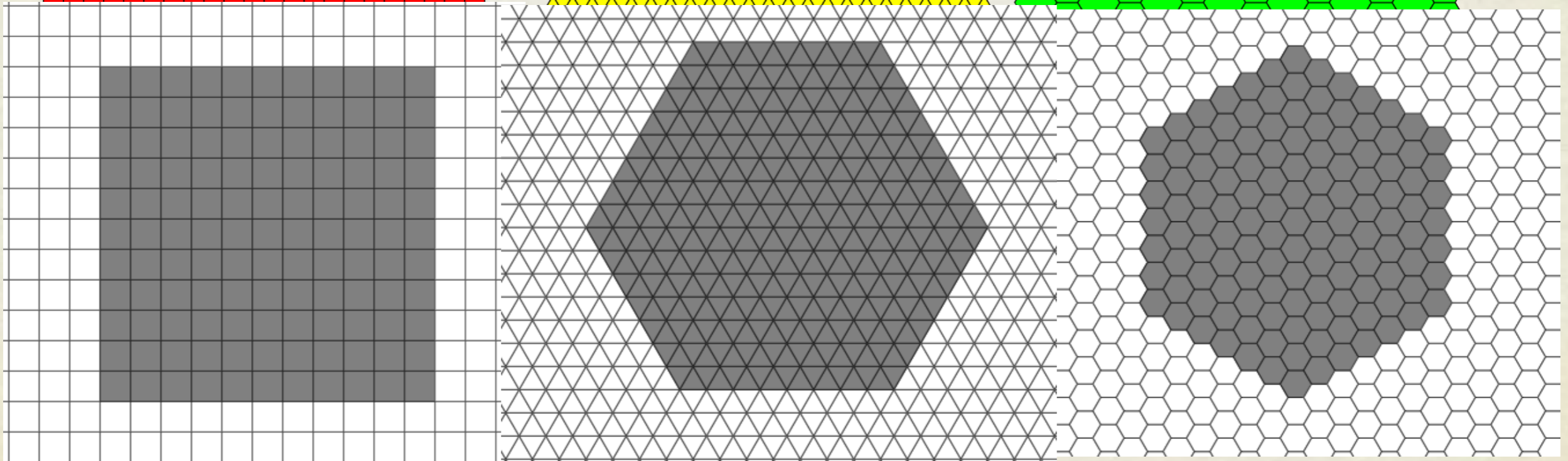
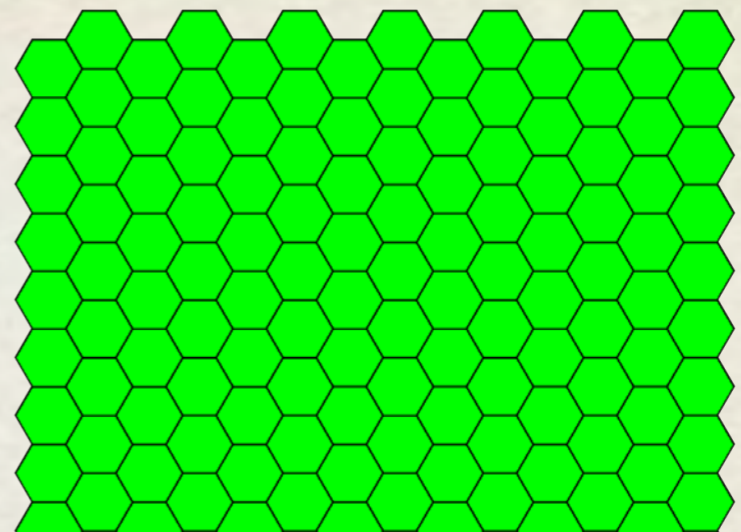
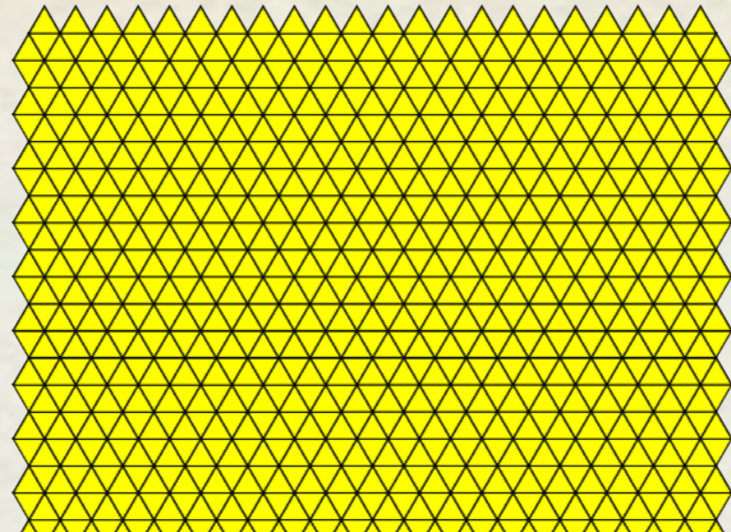
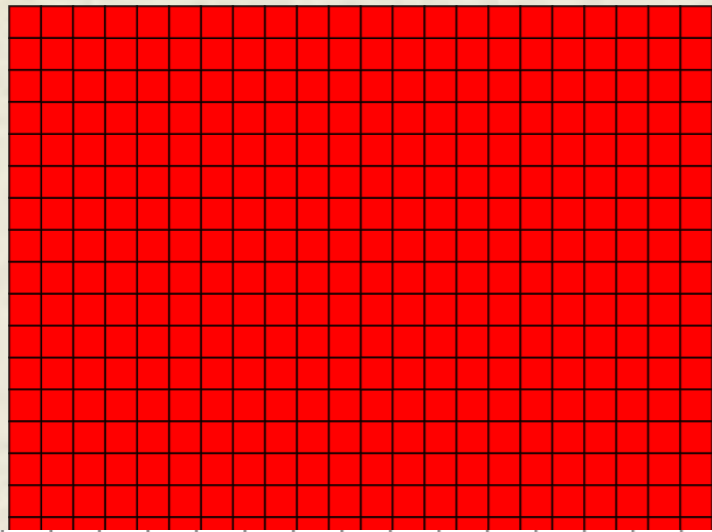
3-corona from a square



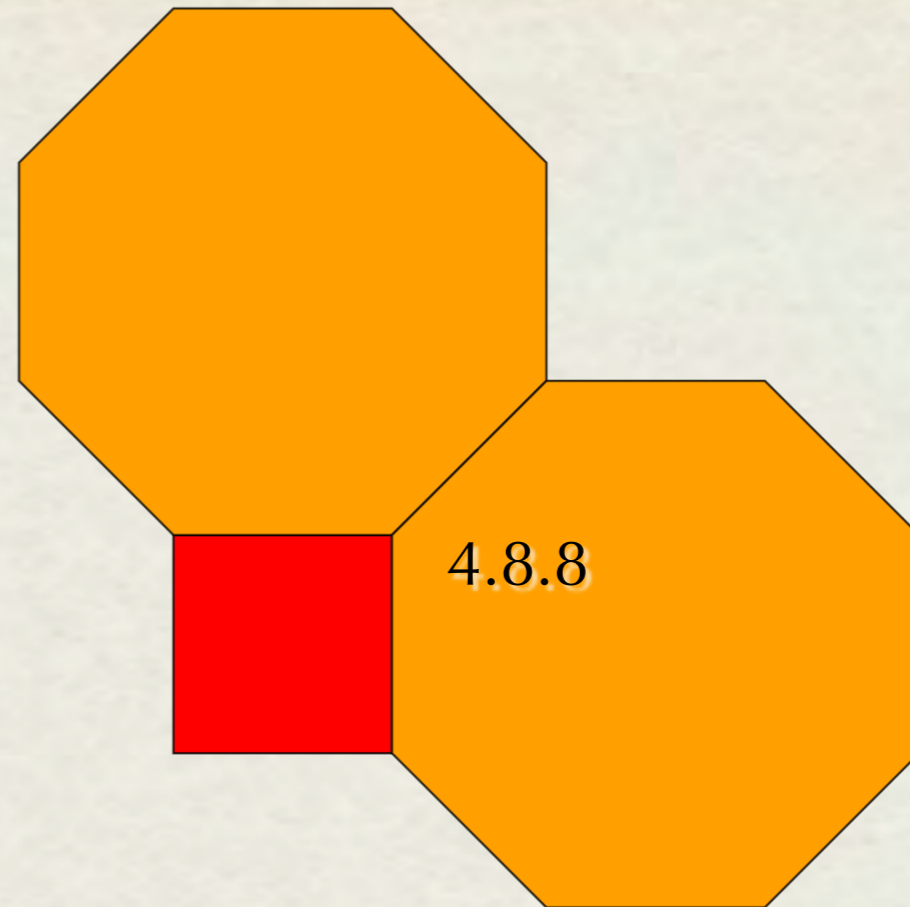
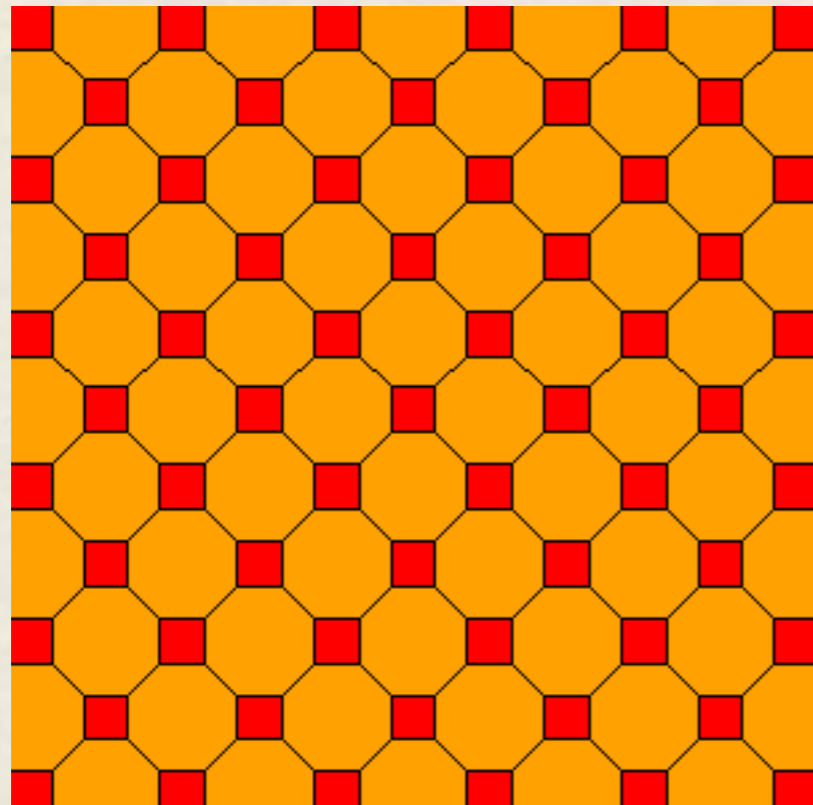
3-edge corona from a square



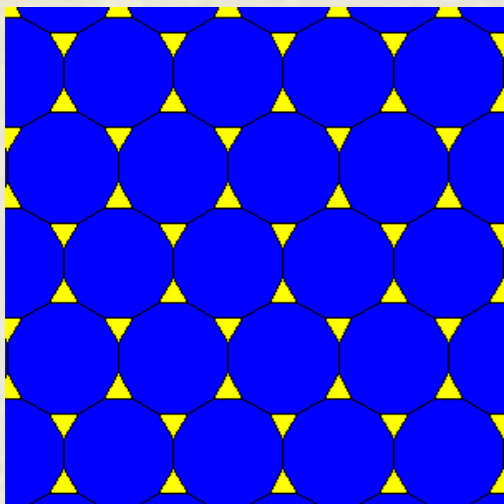
CORONAS OF REGULAR TILINGS



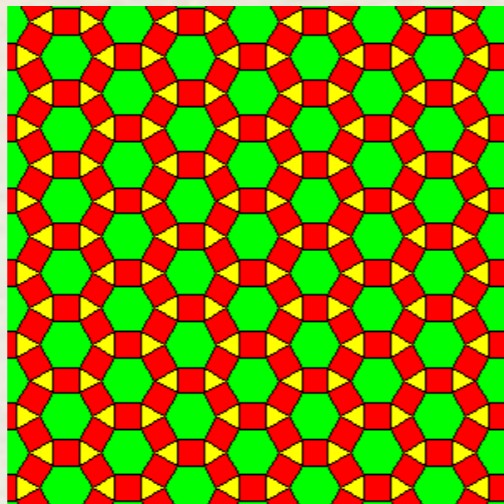
UNIFORM TILING



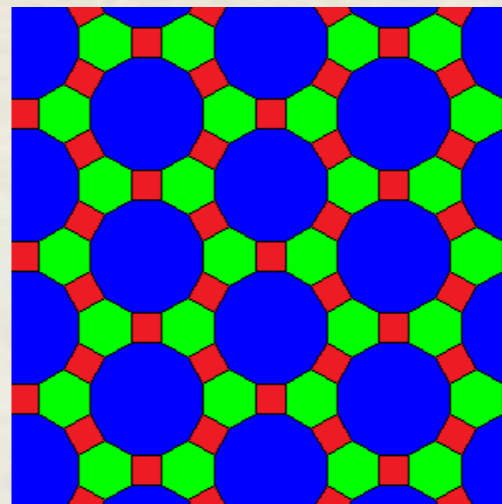
ARCHIMEDEAN TILINGS



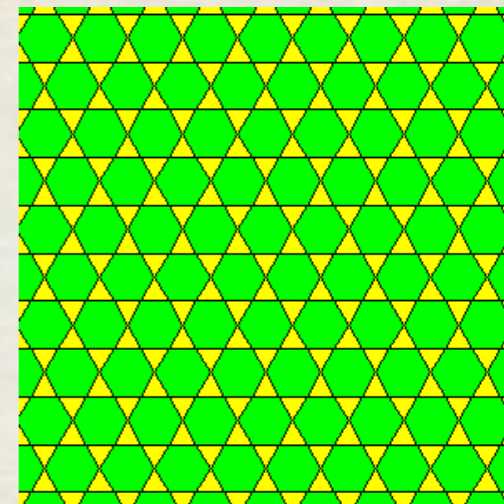
3.12.12



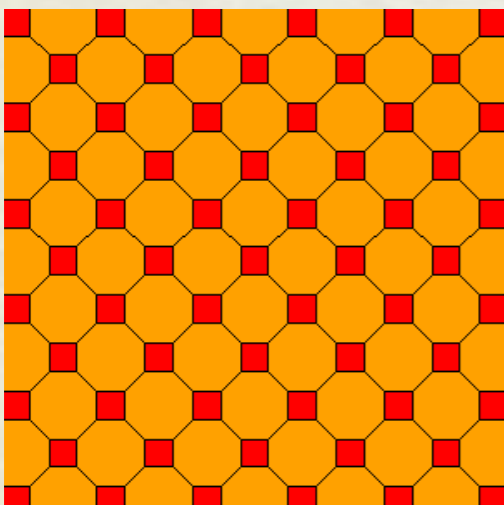
3.4.6.4



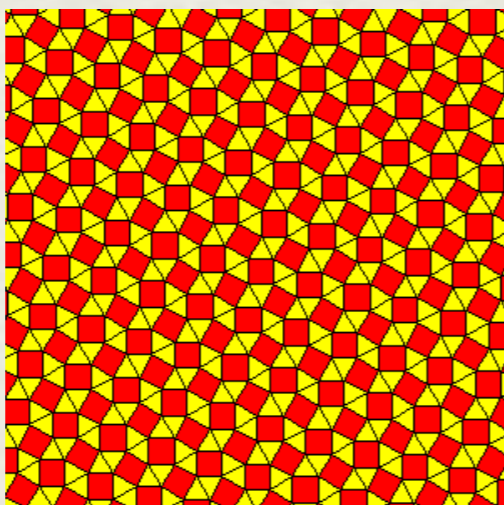
4.6.12



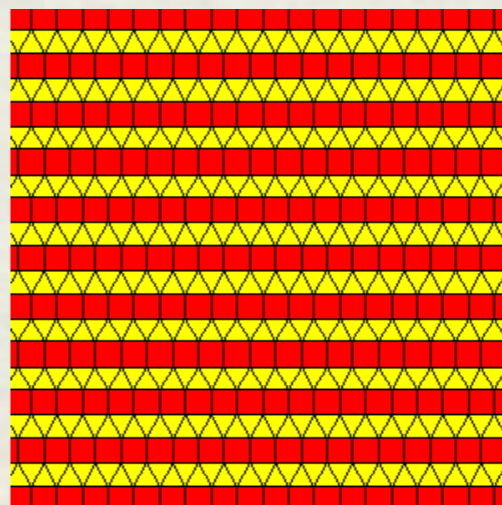
3.6.3.6



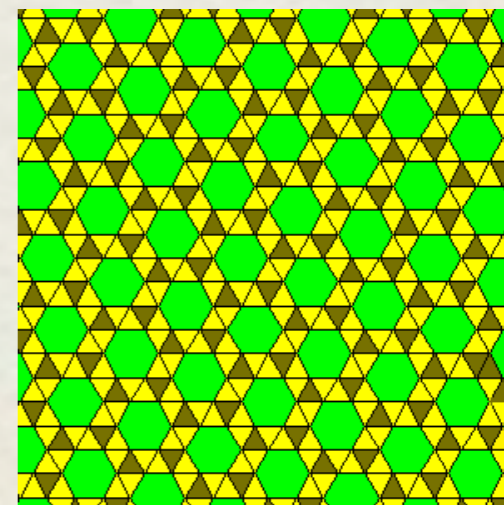
4.8.8



3.3.4.3.4



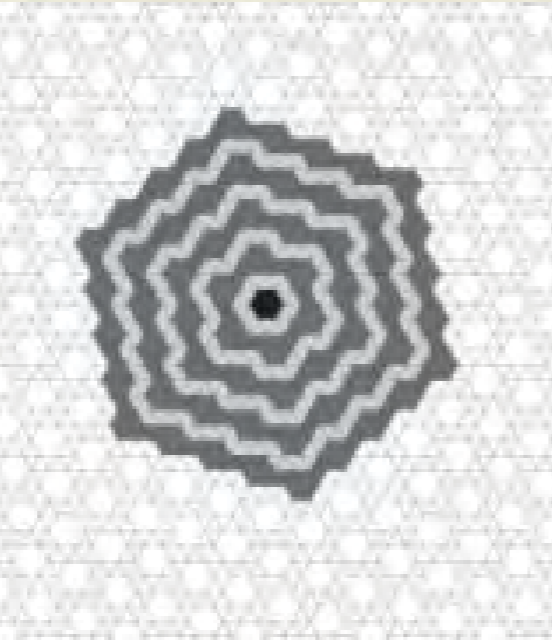
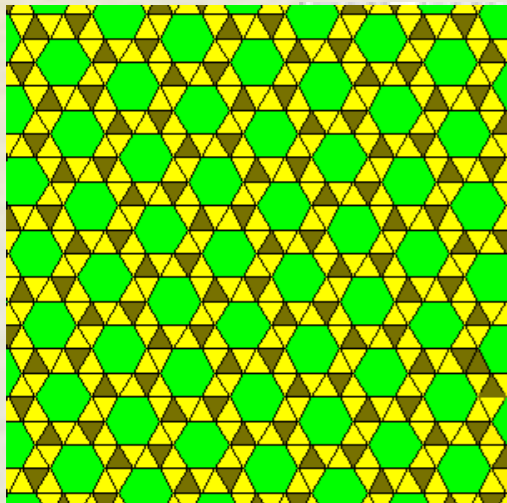
3.3.3.4.4



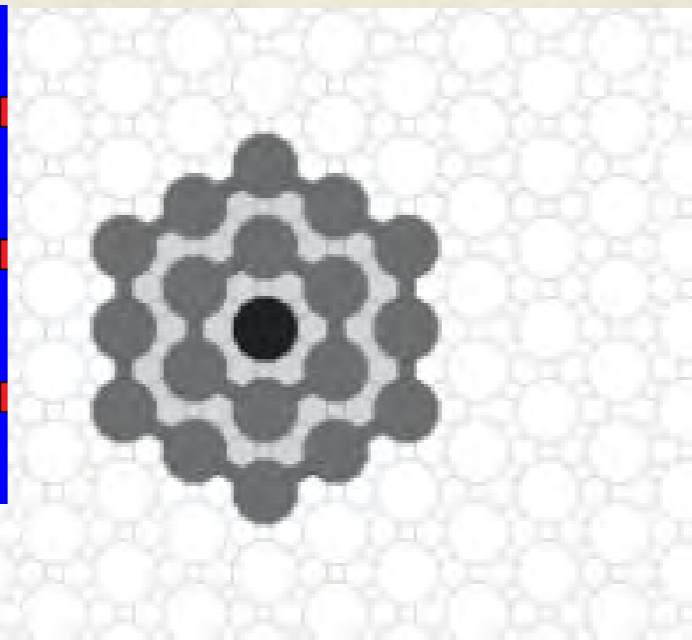
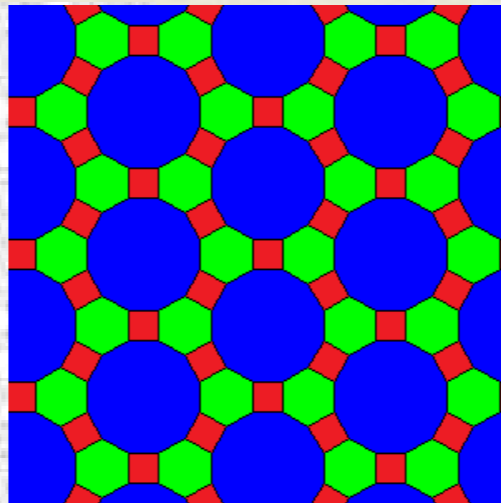
3.3.3.3.6

CORONA OF ALCHMEDAN TILINGS 1

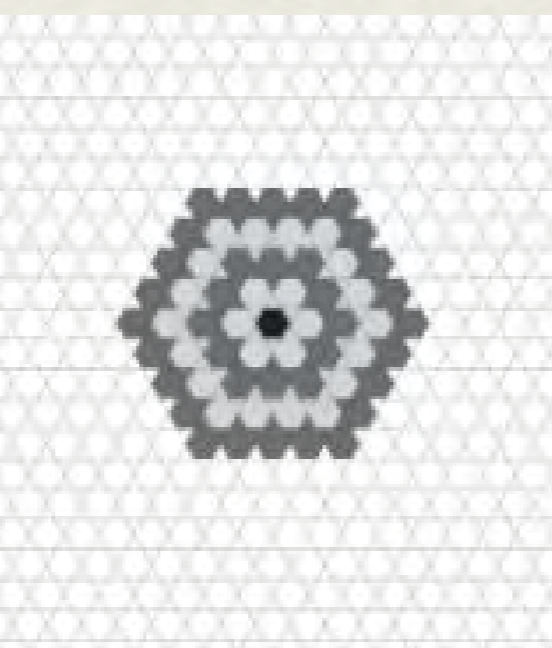
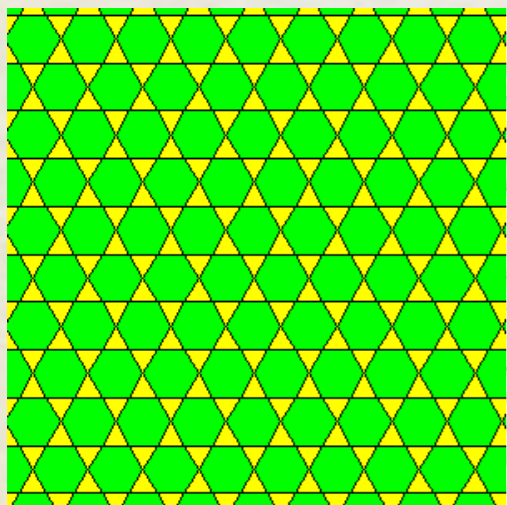
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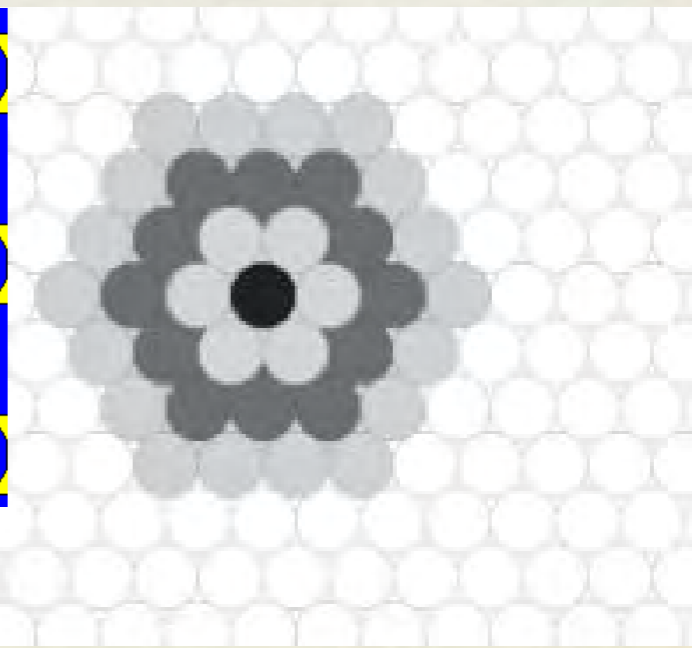
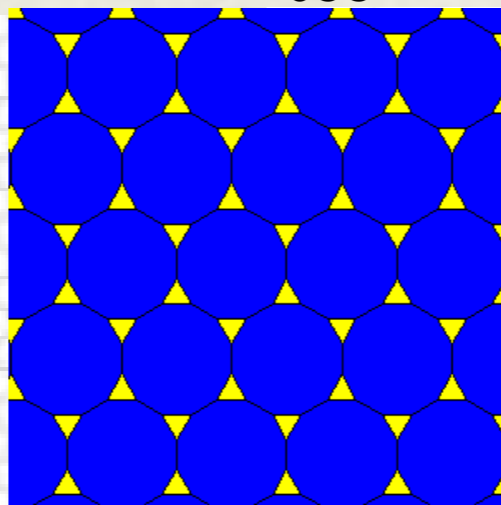
46C



3636

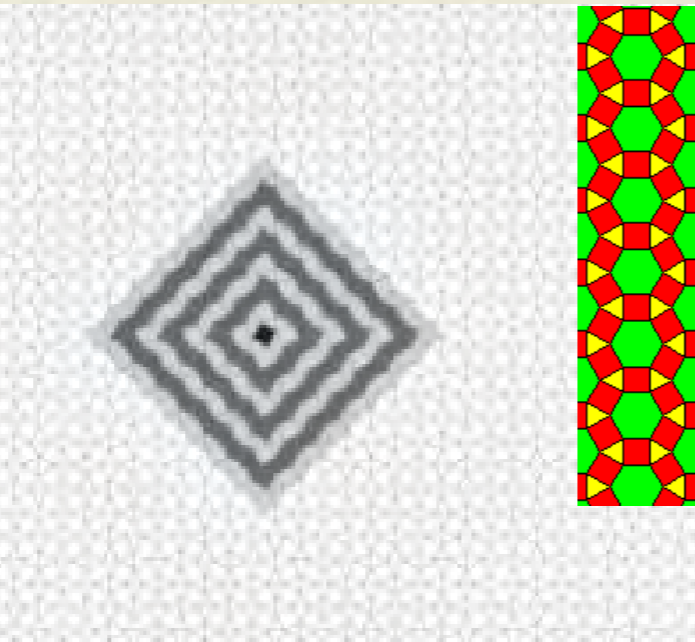
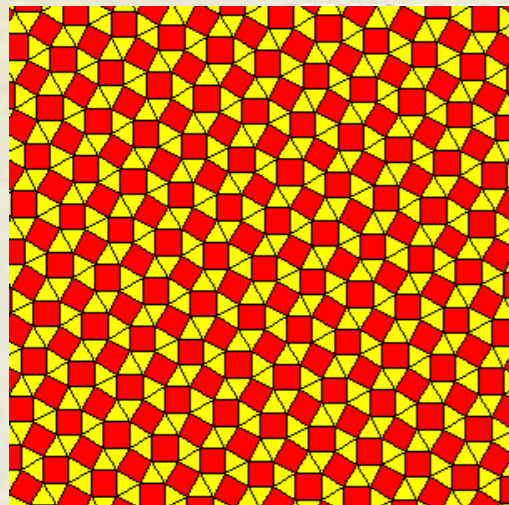


3CC

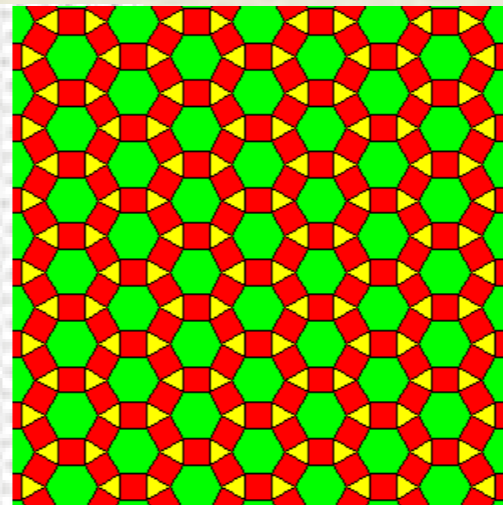


CORONA OF ALCHMEDAN TILINGS 2

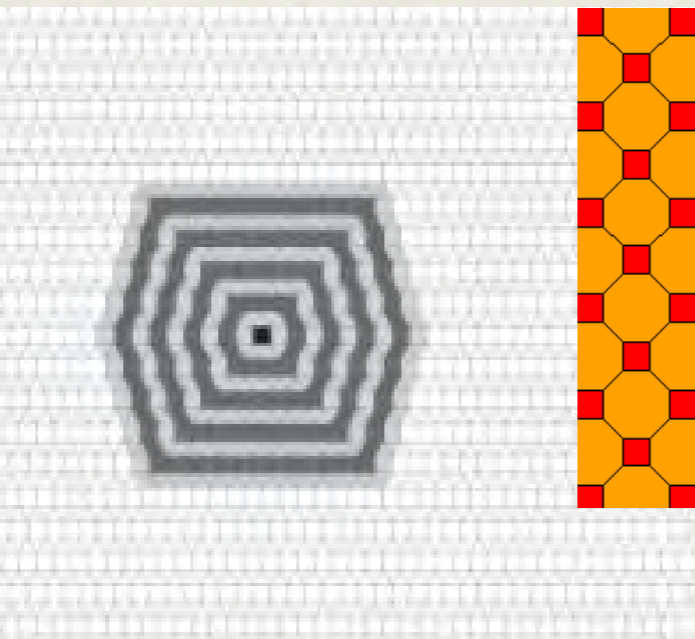
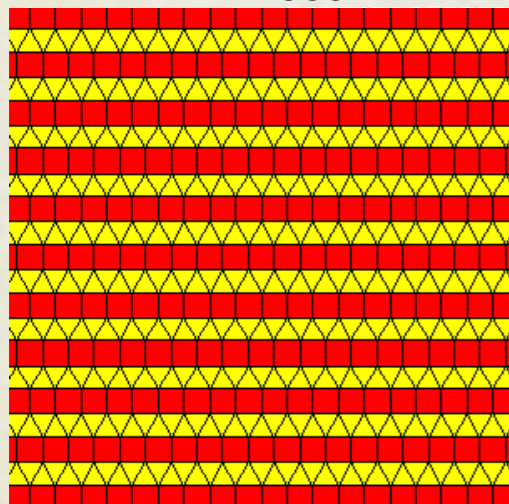
33434



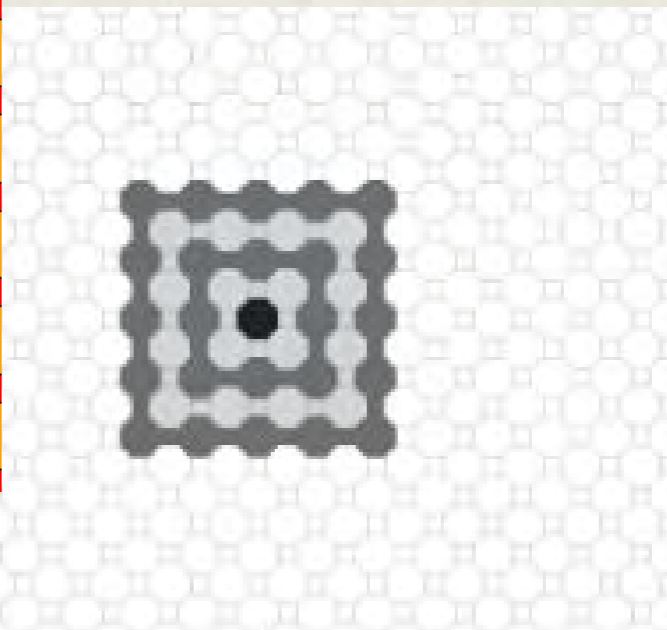
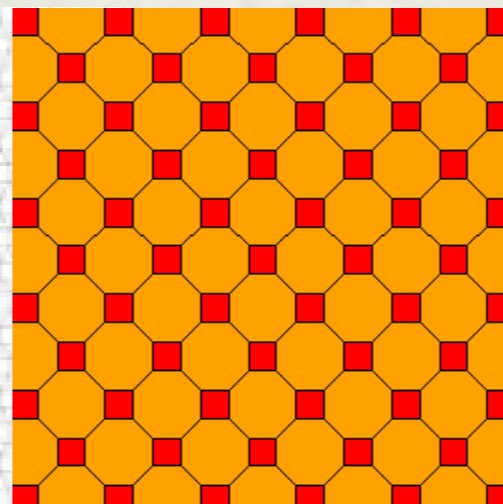
3464



33344

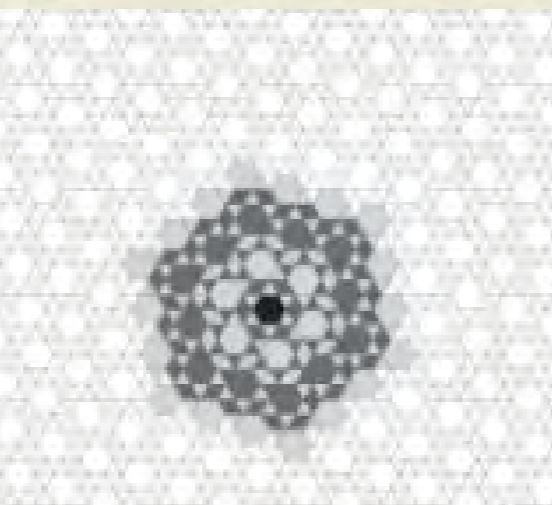
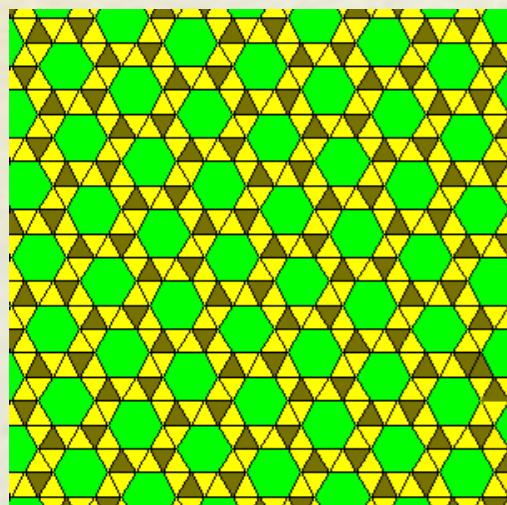


488

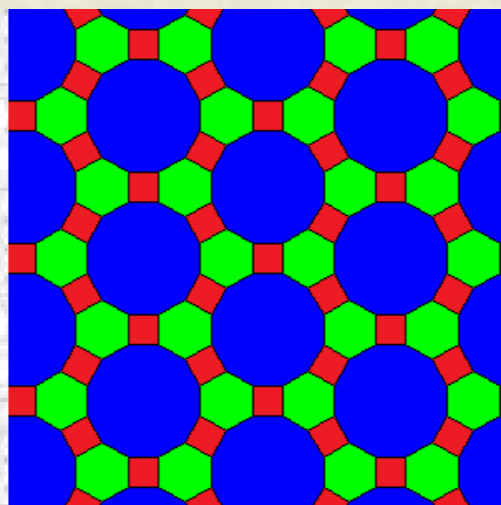


EDGE CORONA OF ALCHMEDAN TILINGS 1

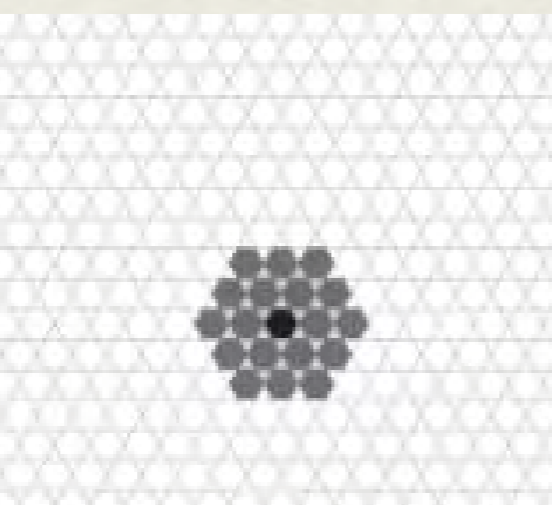
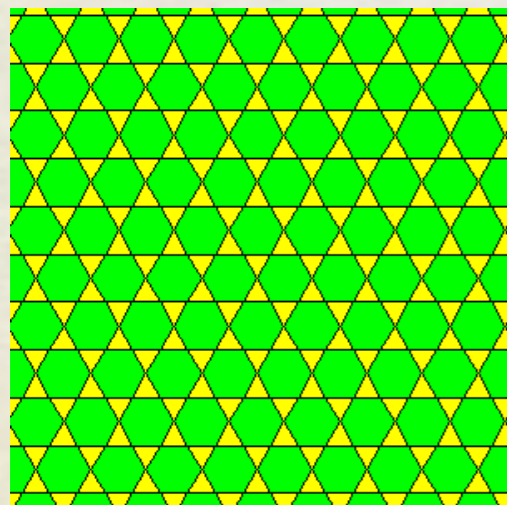
33336



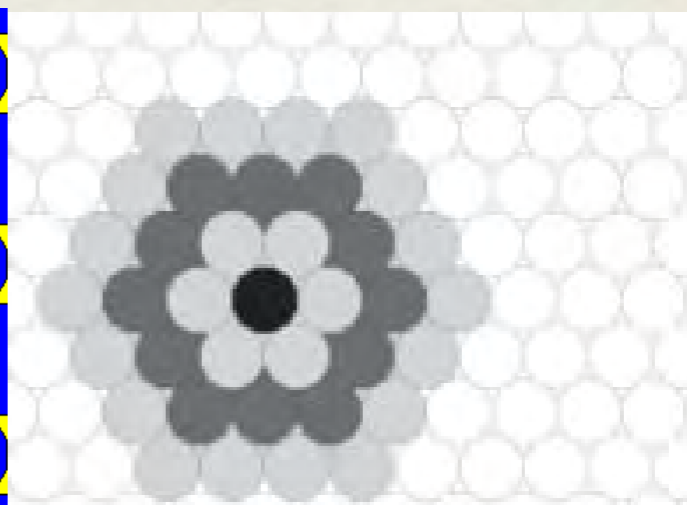
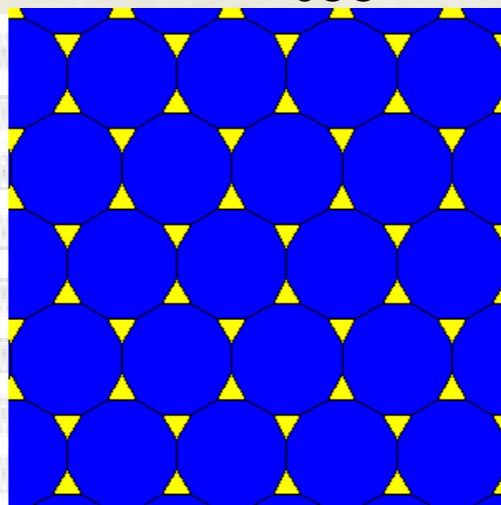
46C



3636

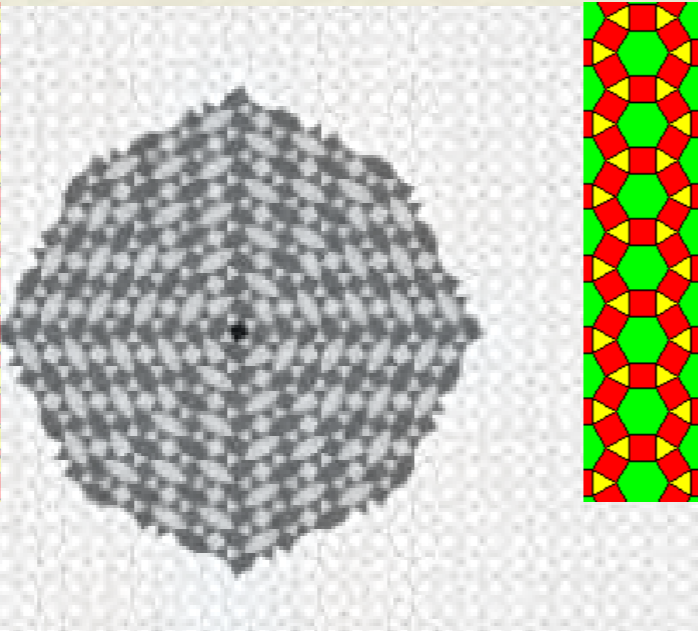
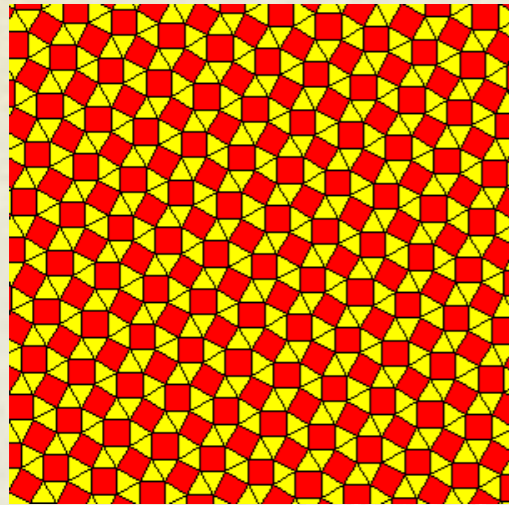


3CC

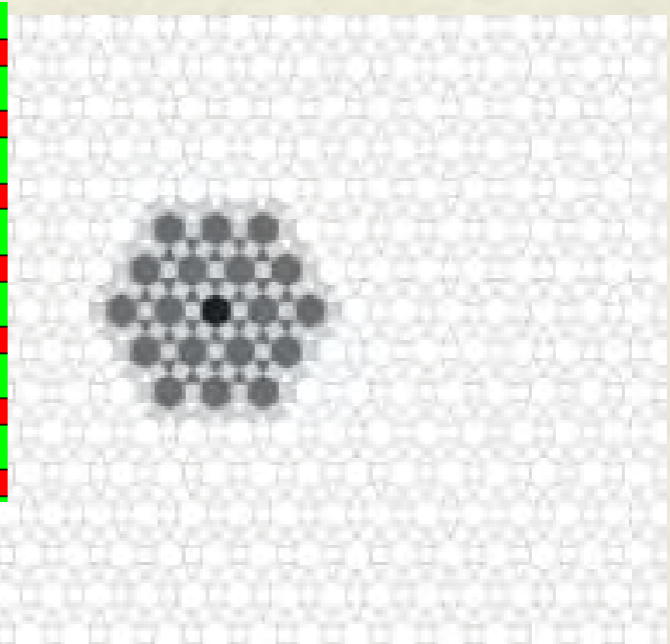
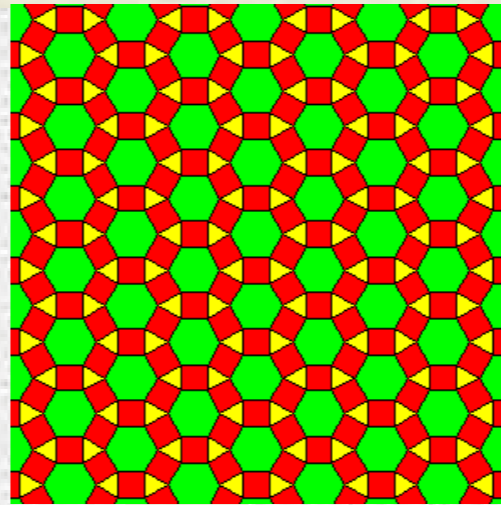


EDGE CORONA OF ALCHMEDAN TILINGS 2

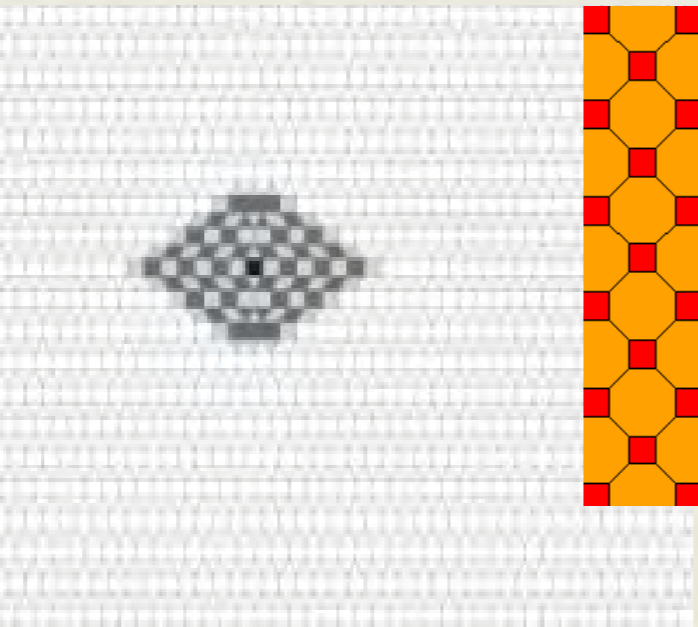
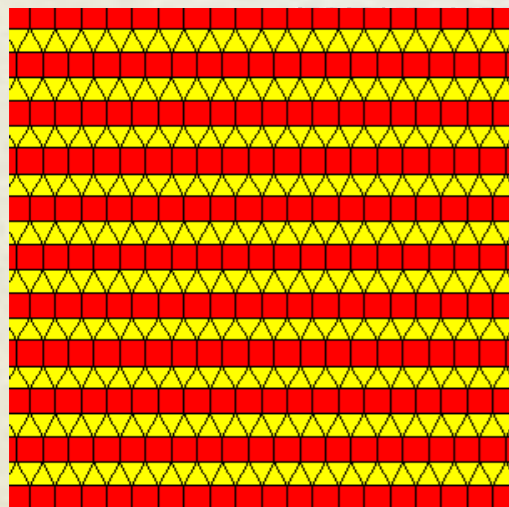
33434



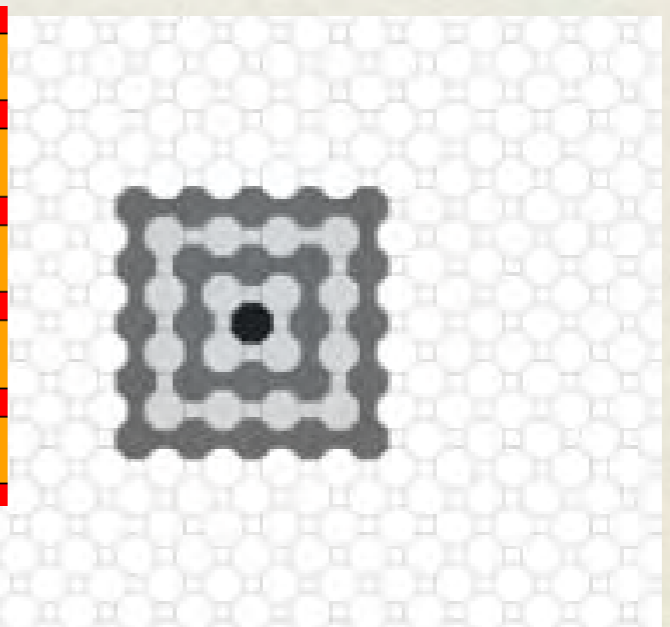
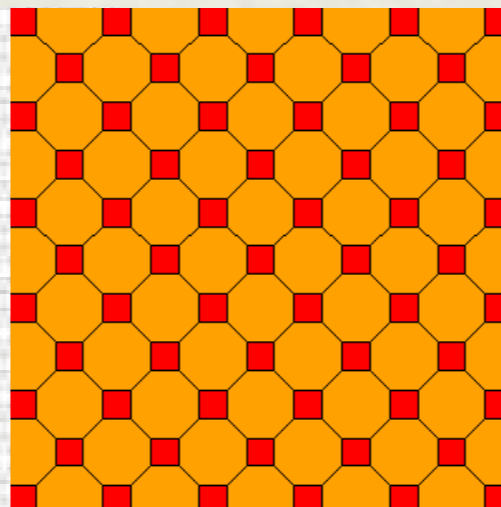
3464



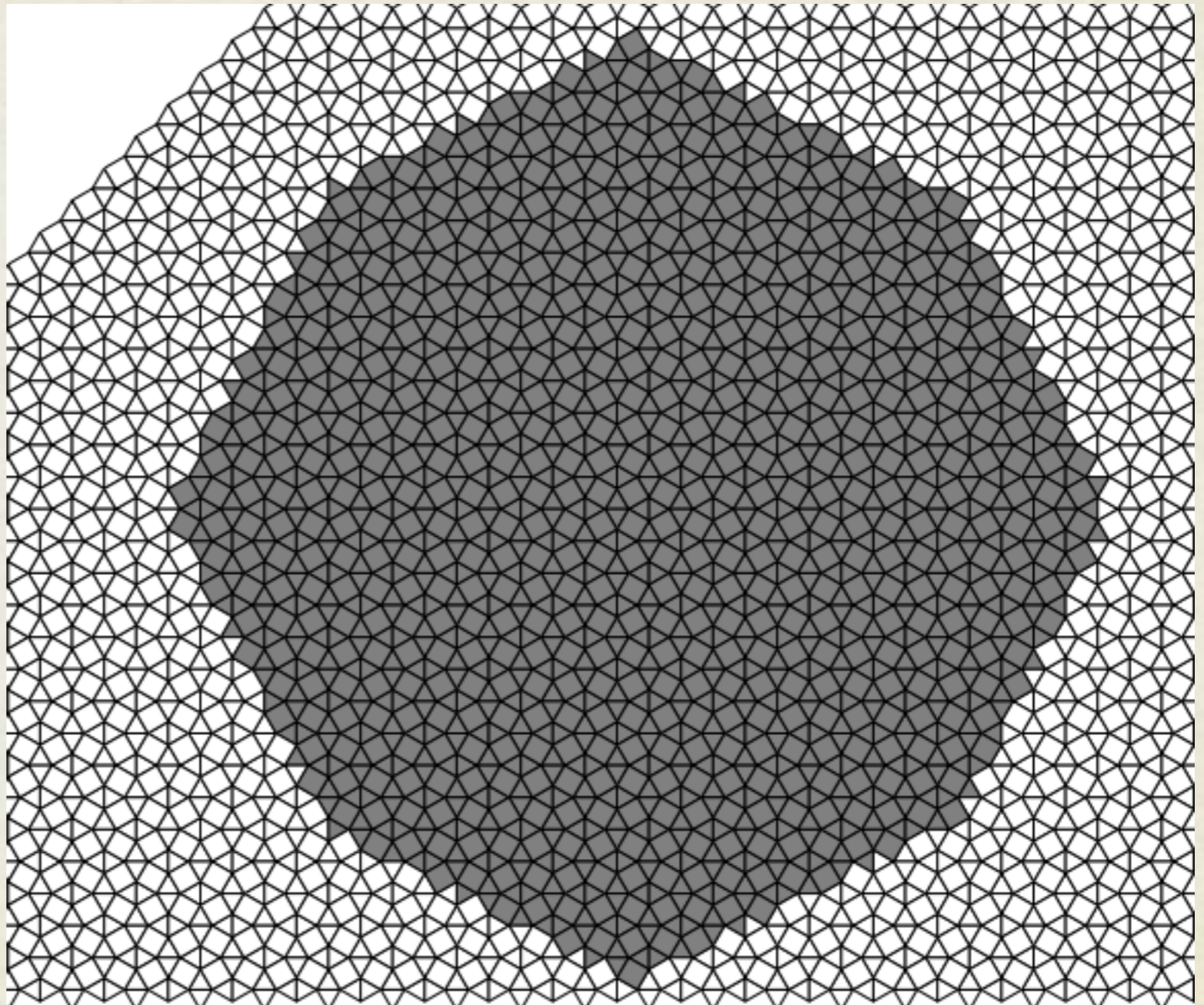
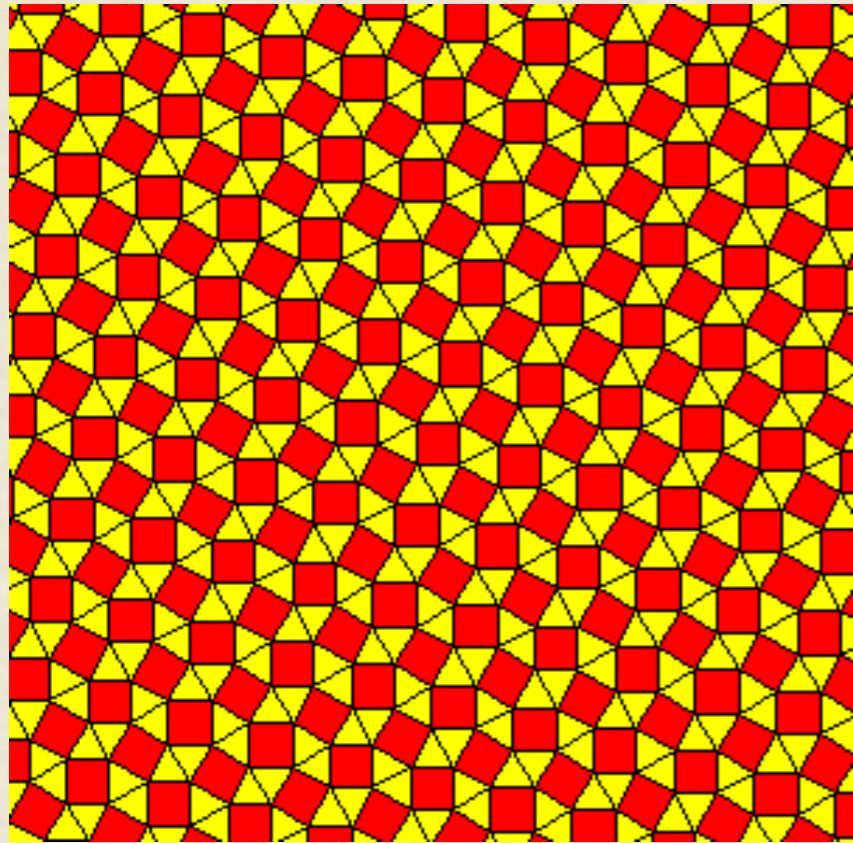
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488

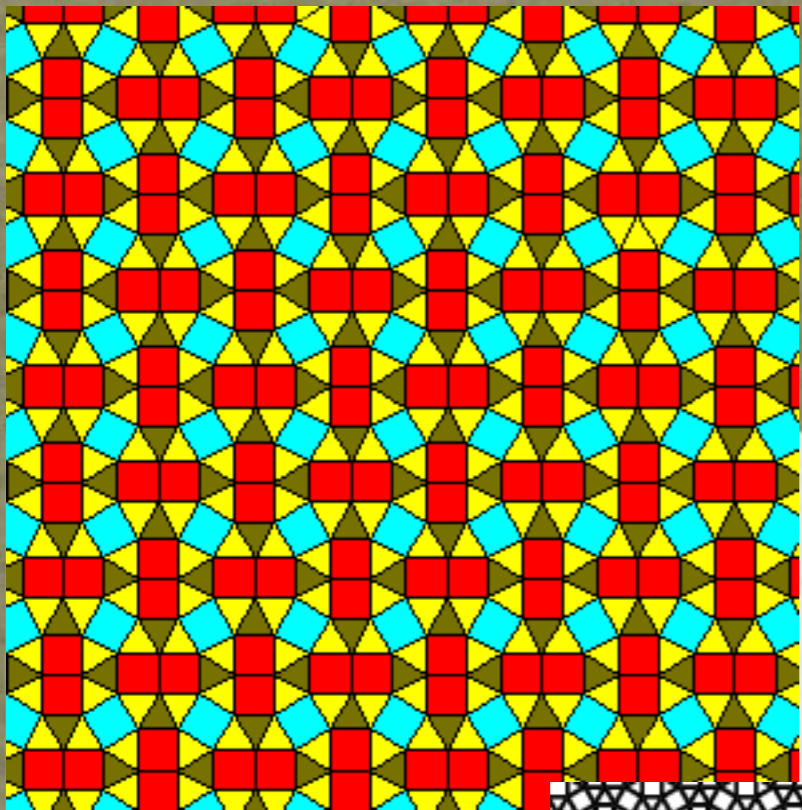


EDGE CORONA OF 33434



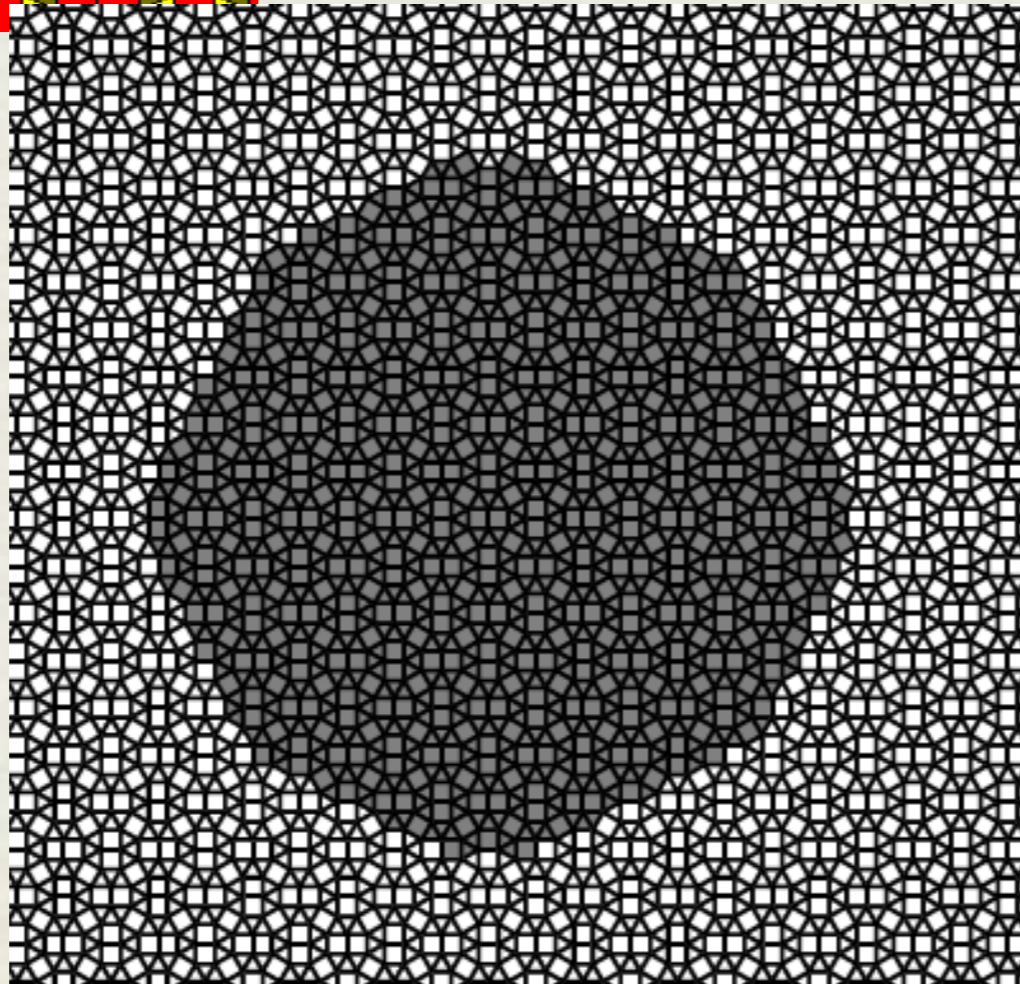
2-UNIFORM TILINGS

p6m, *632						p4m, *442
$[3^6; 3^2.4.3.4]$ (t=3, e=3)	$[3.4.6.4; 3^2.4.3.4]$ (t=4, e=4)	$[3.4.6.4; 3^3.4^2]$ (t=4, e=4)	$[3.4.6.4; 3.4^2.6]$ (t=5, e=5)	$[4.6.12; 3.4.6.4]$ (t=4, e=4)	$[3^6; 3^2.4.12]$ (t=4, e=4)	$[3.12.12; 3.4.3.12]$ (t=3, e=3)
p6m, *632	p6, 632	p6, 632	cmm, 2*22	pmm, *2222	cmm, 2*22	pmm, *2222
$[3^6; 3^2.6^2]$ (t=2, e=3)	$[3^6; 3^4.6]_1$ (t=3, e=3)	$[3^6; 3^4.6]_2$ (t=5, e=7)	$[3^2.6^2; 3^4.6]$ (t=2, e=4)	$[3.6.3.6; 3^2.6^2]$ (t=2, e=3)	$[3.4^2.6; 3.6.3.6]_2$ (t=3, e=4)	$[3.4^2.6; 3.6.3.6]_1$ (t=4, e=4)
p4g, 4*2	pgg, 2x	cmm, 2*22	cmm, 2*22	pmm, *2222	cmm, 2*22	
$[3^3.4^2; 3^2.4.3.4]_1$ (t=4, e=5)	$[3^3.4^2; 3^2.4.3.4]_2$ (t=3, e=6)	$[4^4; 3^3.4^2]_1$ (t=2, e=4)	$[4^4; 3^3.4^2]_2$ (t=3, e=5)	$[3^6; 3^3.4^2]_1$ (t=3, e=4)	$[3^6; 3^3.4^2]_2$ (t=4, e=5)	

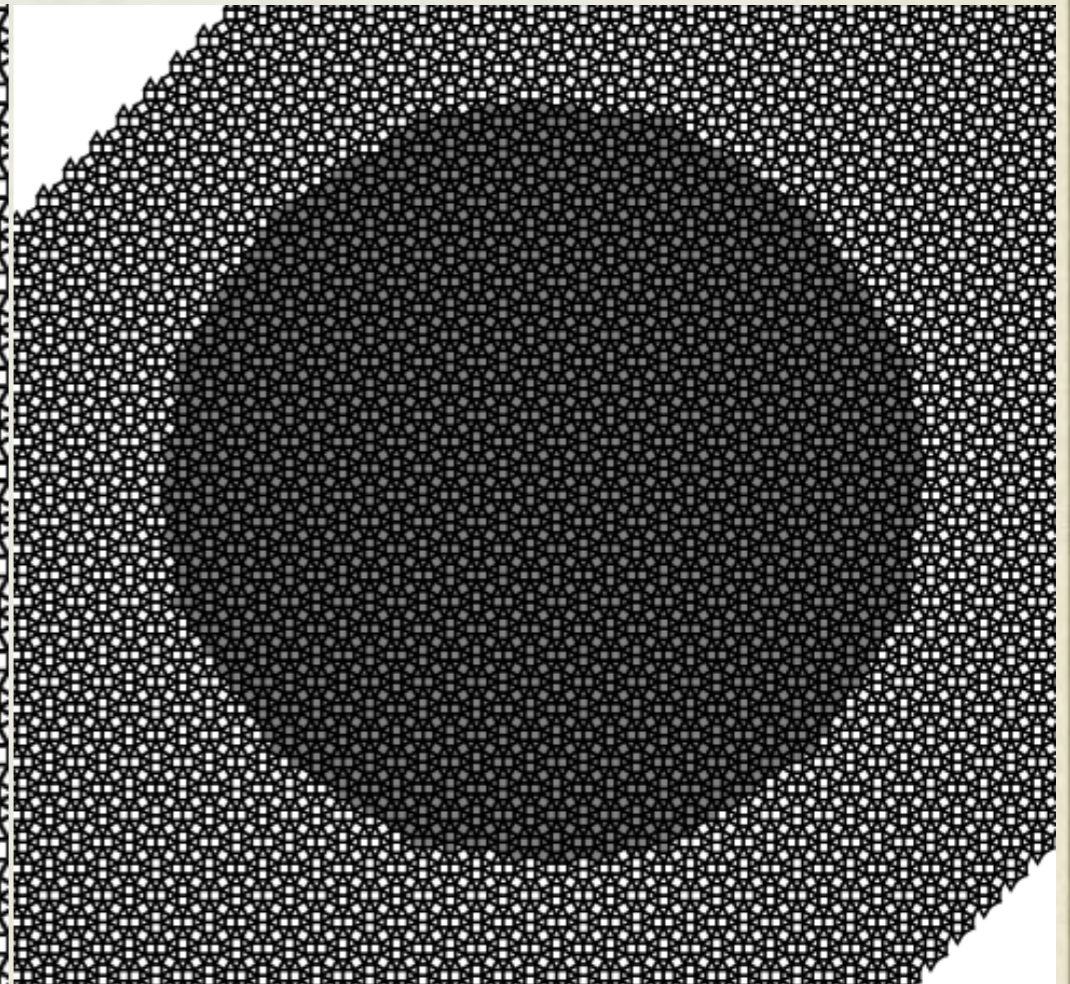


corona

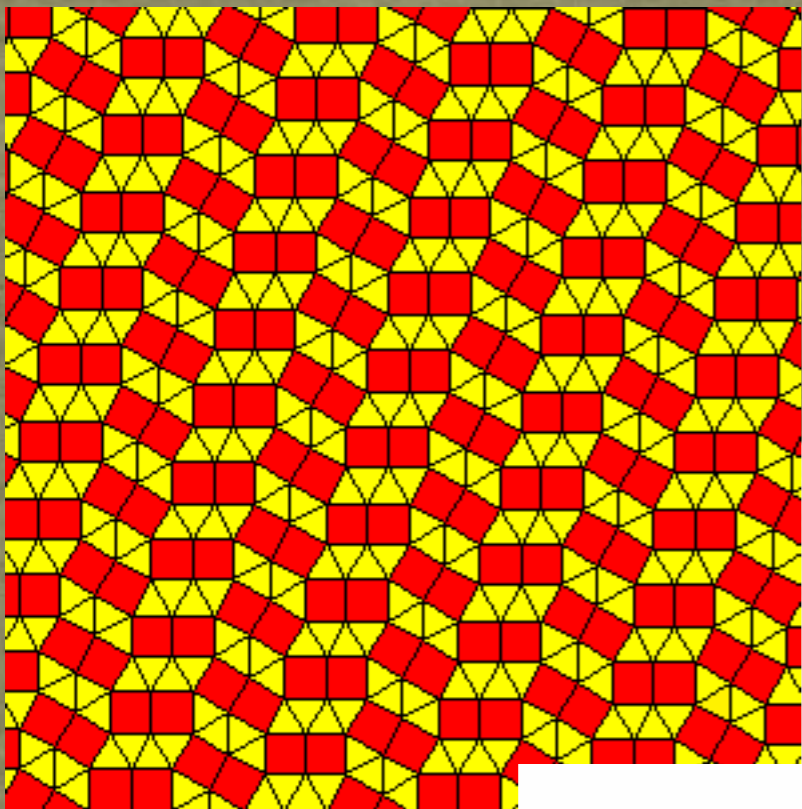
edge corona



octagon

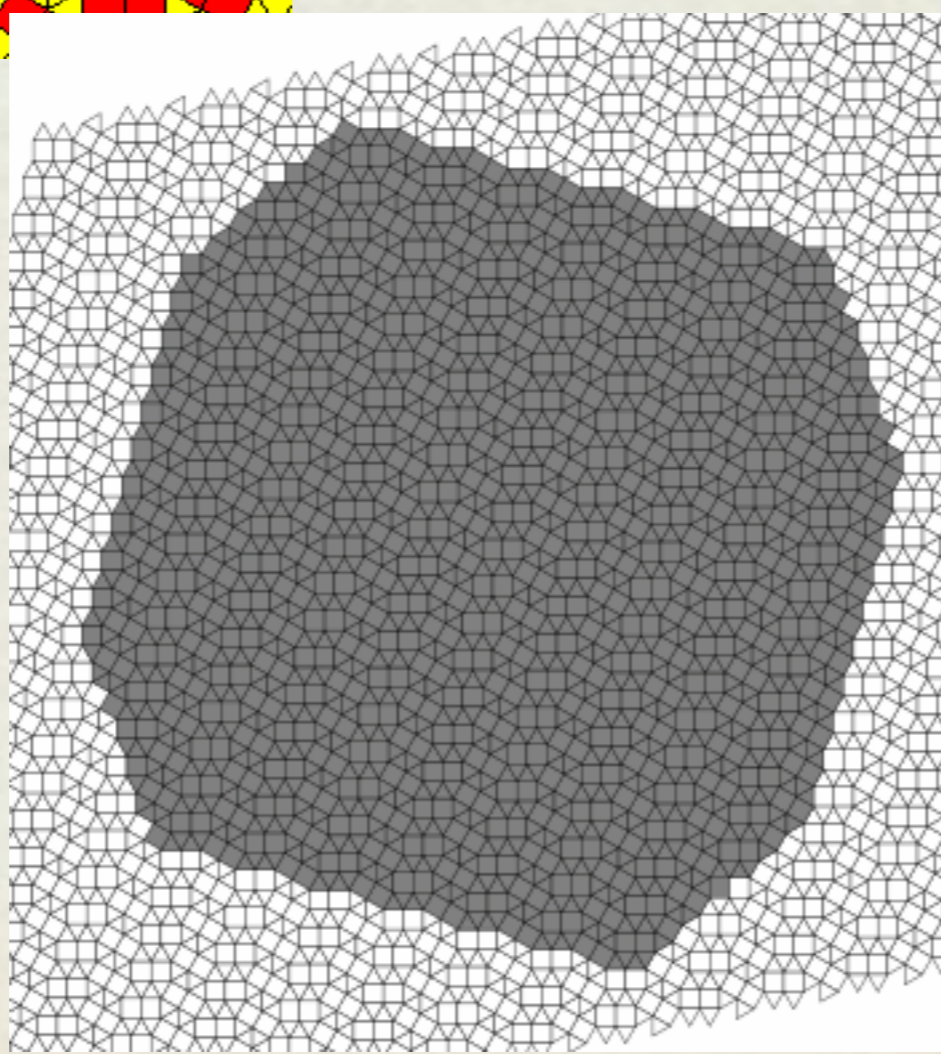


hexadecagon

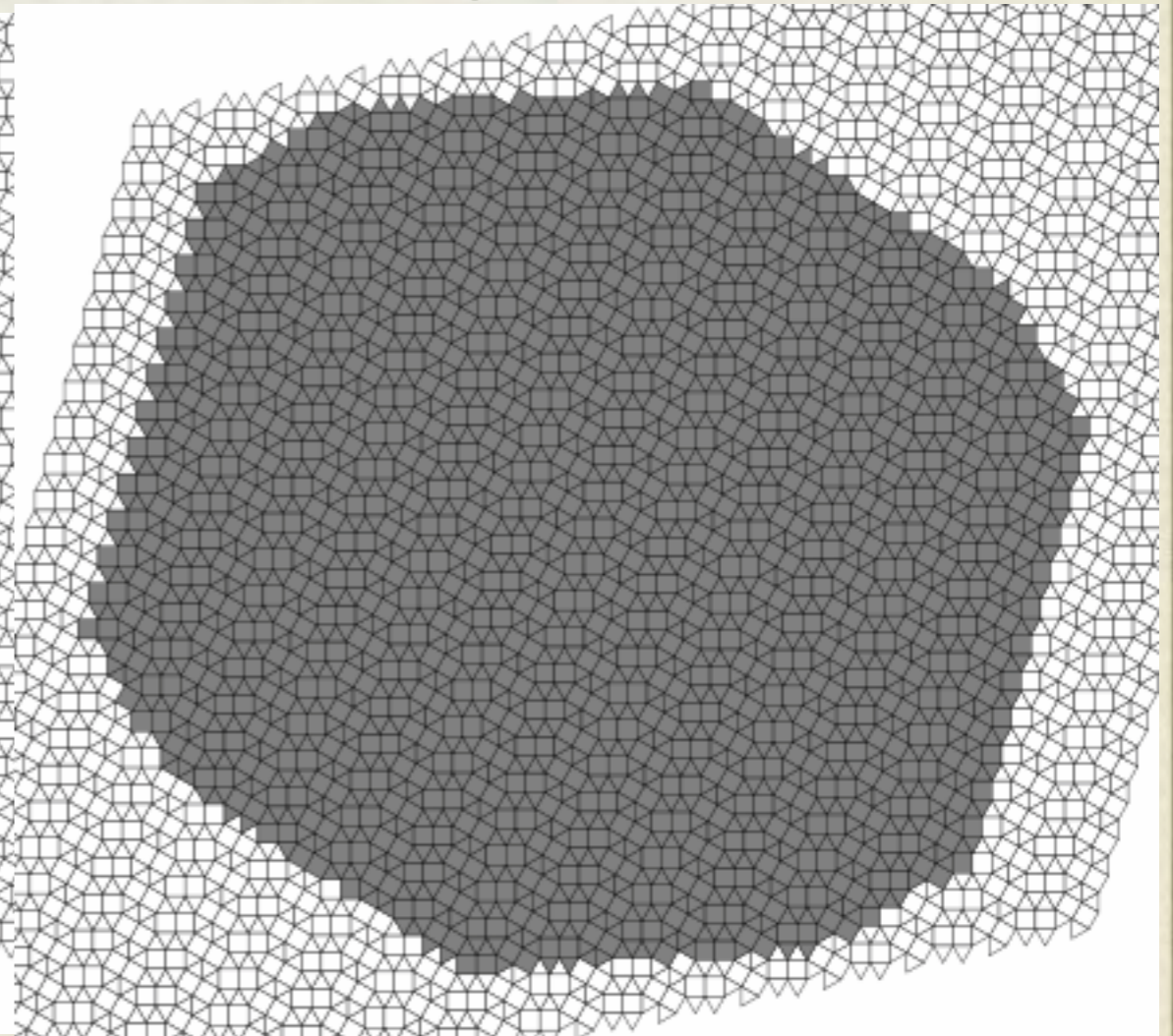


corona

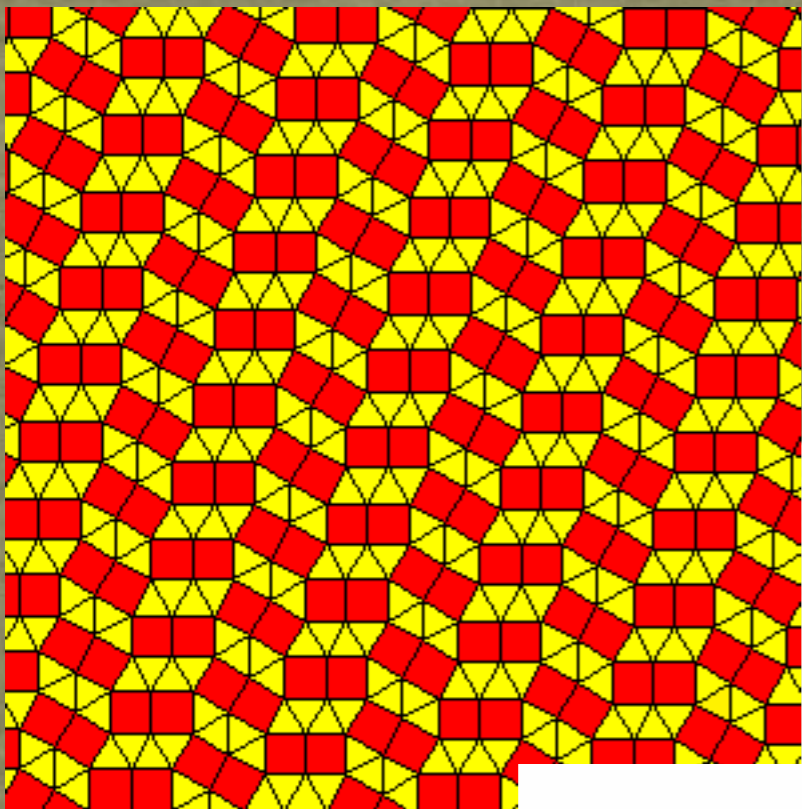
edge corona



octagon

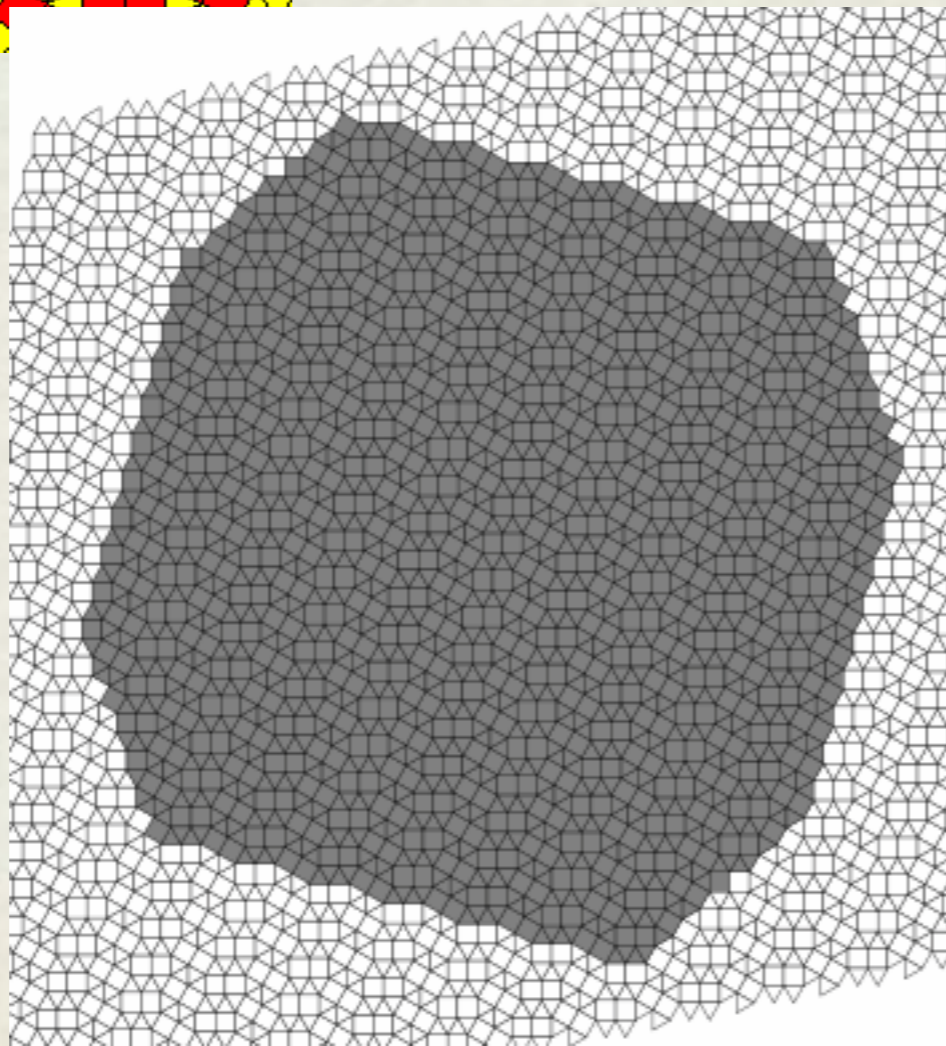


hexadecagon

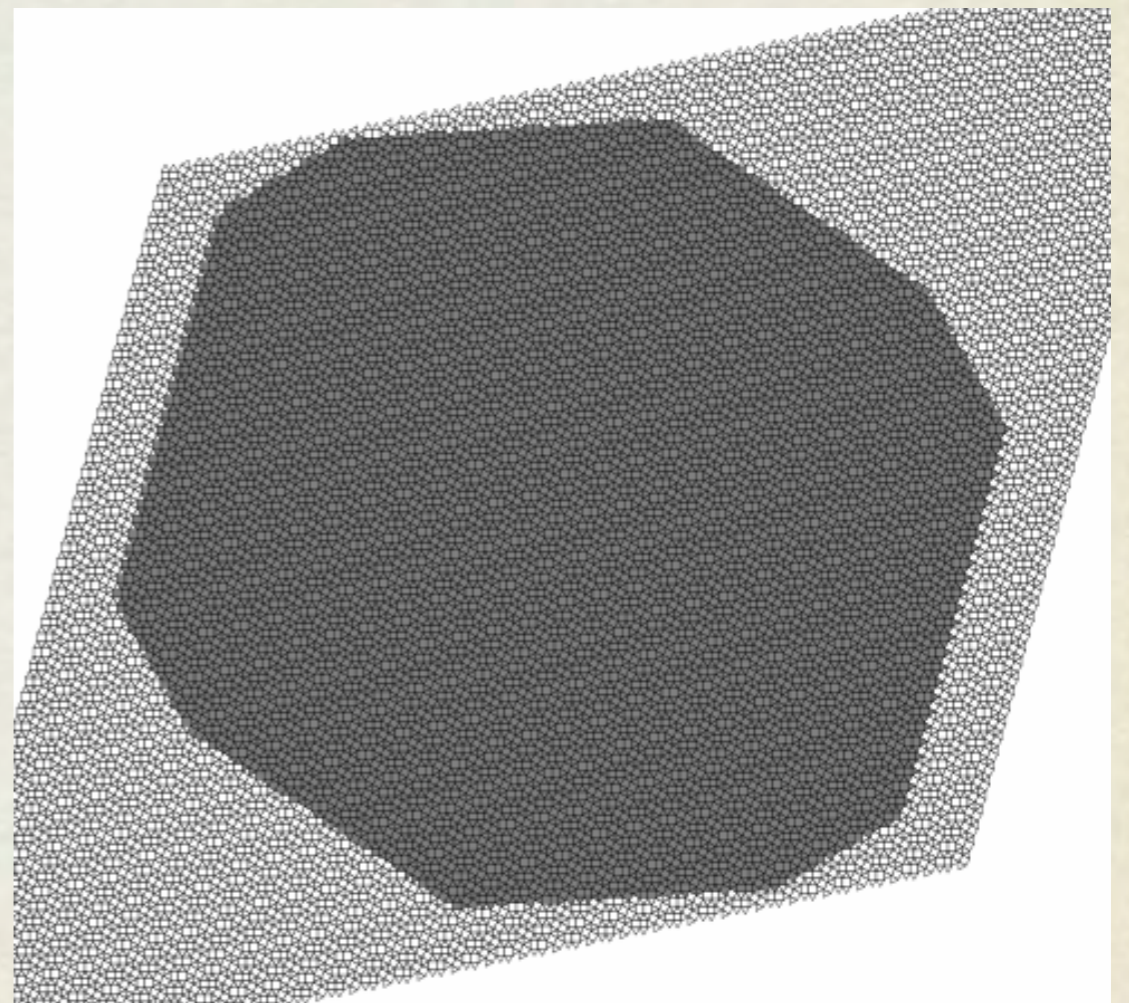


corona

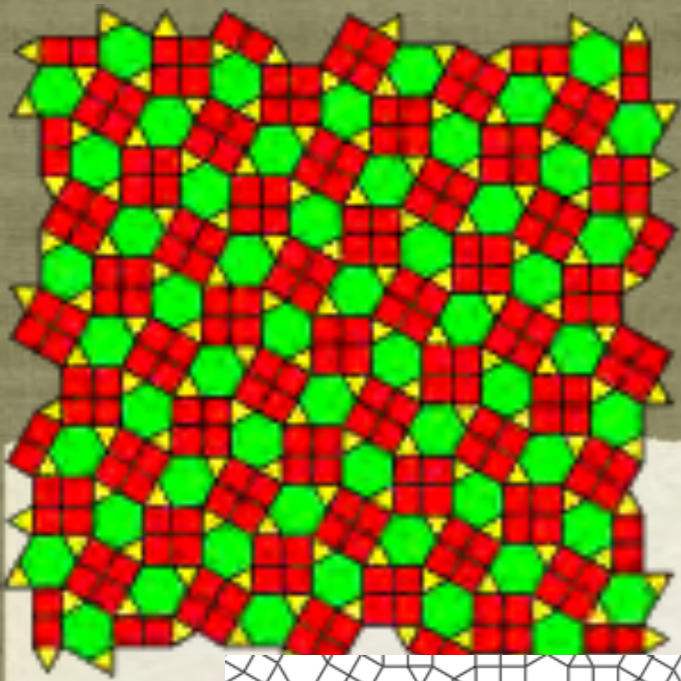
edge corona



octagon

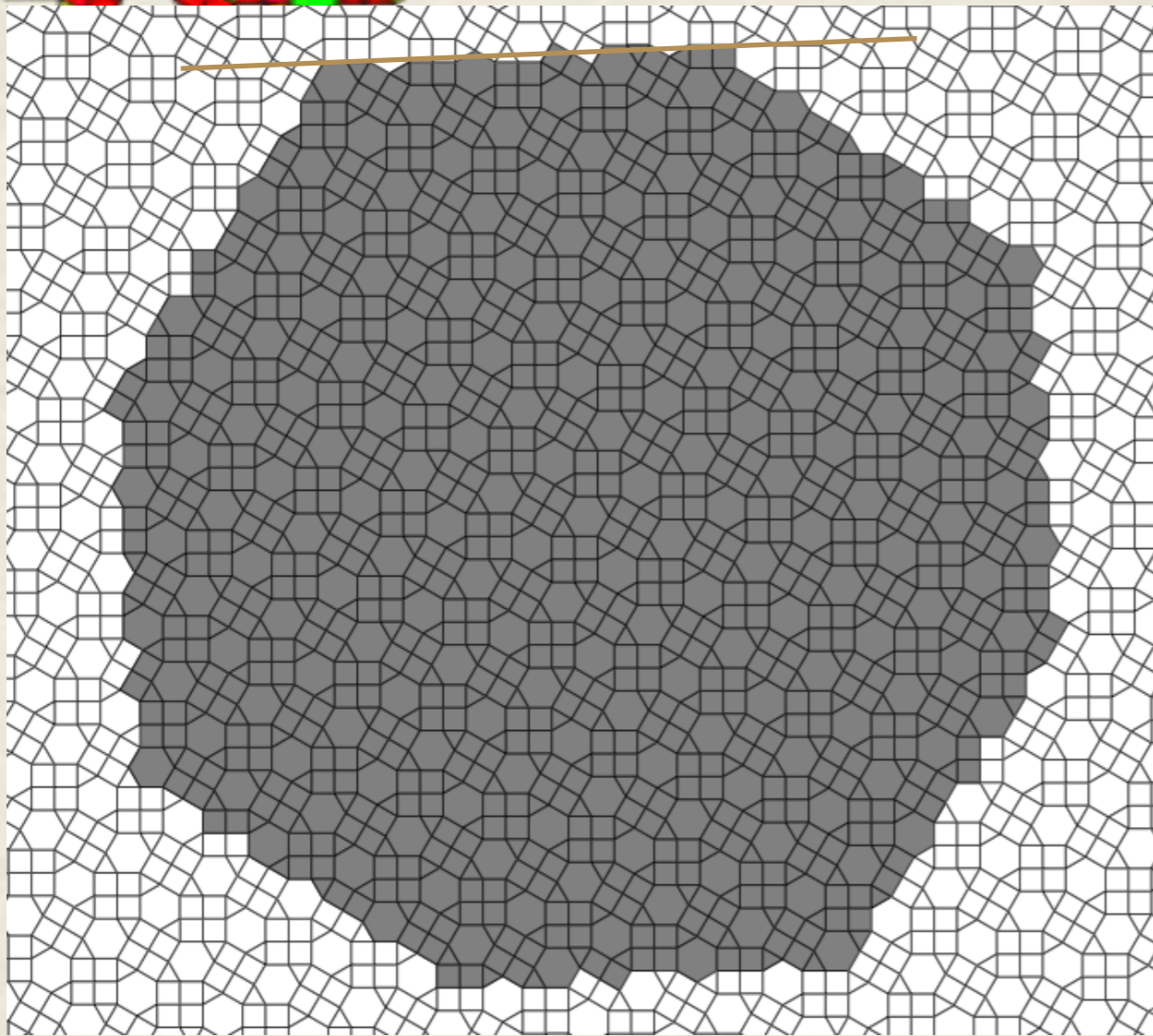


decagon

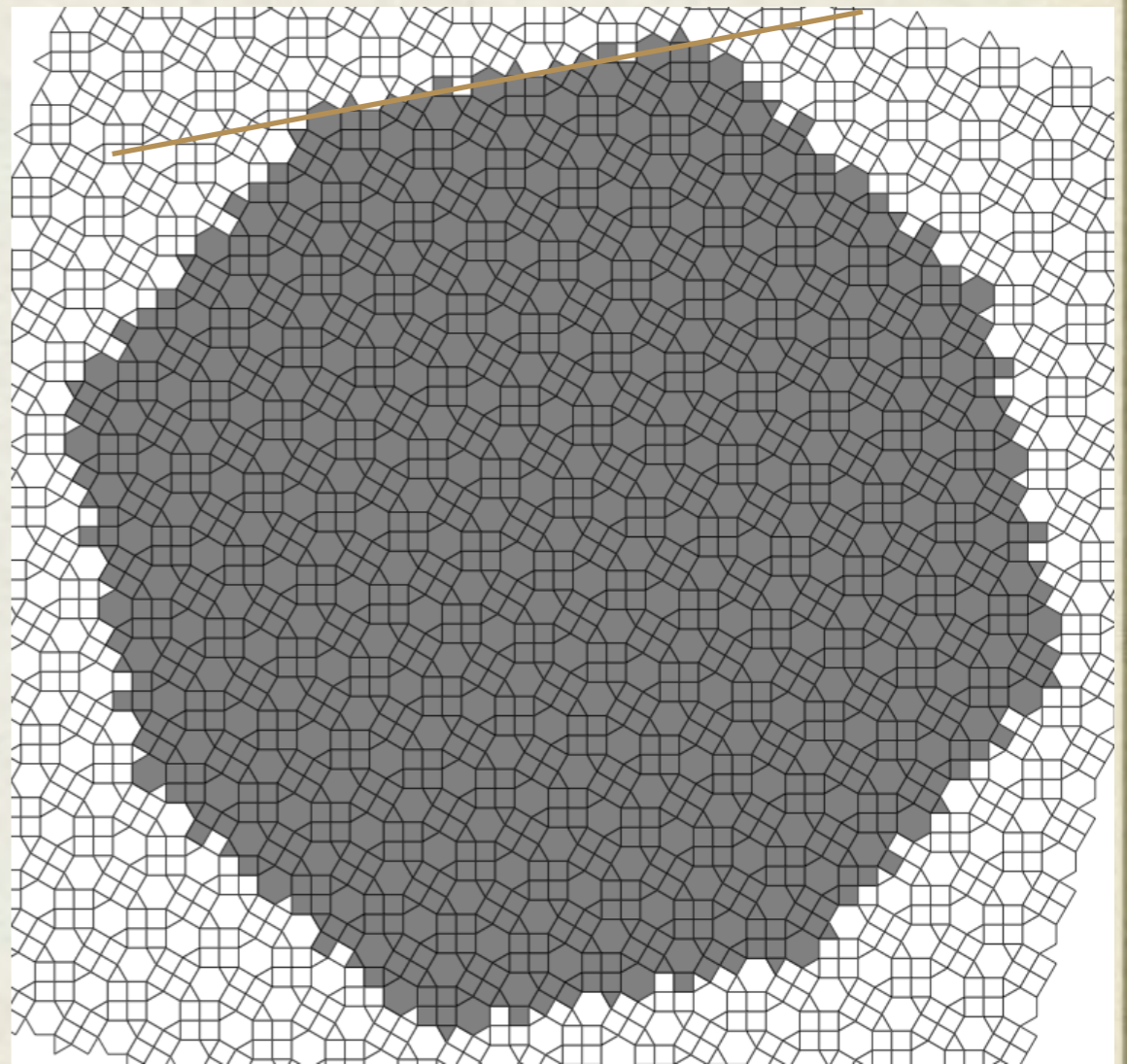


corona

edge corona



octagon



octagon

I am lucky if some of you feel a sense of wonder in my talk.

But I actually hope each of you are feeling a sense of wonder in another topic of which I do not notice the interestingness at all.

Thank you.