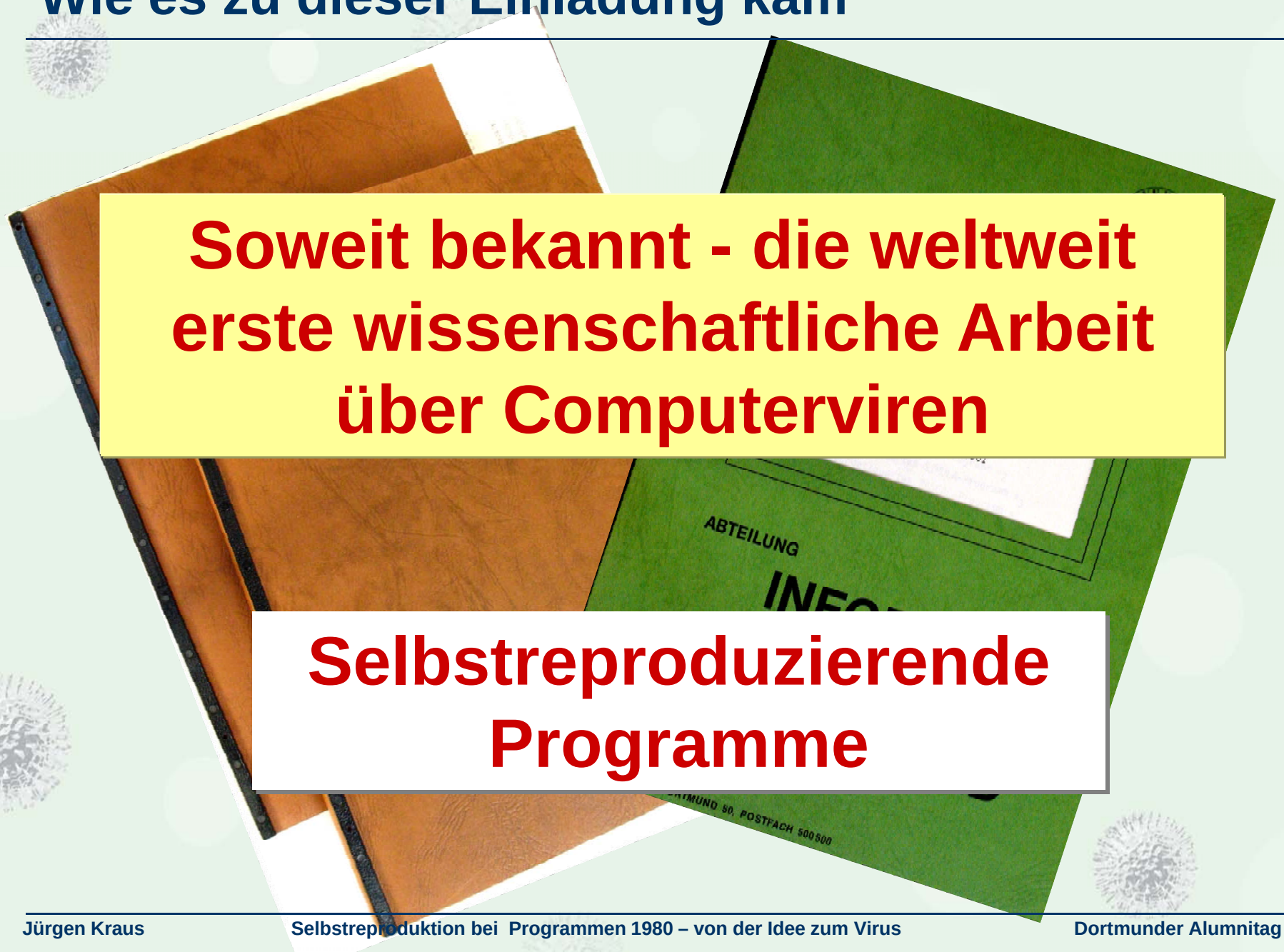
Selbstreproduktion bei Programmen
--- 1980 ---
von einer Idee zum Virus

Wie es zu dieser Einladung kam

Wie es zu dieser Einladung kam



Soweit bekannt - die weltweit erste wissenschaftliche Arbeit über Computerviren

Selbstreproduzierende Programme

Wie es zu dieser Diplomarbeit kam

Ende er 70`er Jahre

Immer leistungsfähigere Computersysteme (IBM 360, Pdp-11)

Erste Computernetzwerke (Projekt „Rechner-Kopplung“ UniDo)

Gestiegene *Komplexität* in der digitalen Welt

Science-Fiction Themen:

„Computer geraten außer Kontrolle“

„Computer ergreifen die Macht“

„Computer führen ihr *Eigenleben*“

Wie es zu dieser Diplomarbeit kam

Naturphilosophischer Gedanke:

„Entstehung von ist auch eine Folge von “

Beispiel: Die Entstehung irdischen Lebens

→Urknall

→Entstehung der Elemente

→Kosmochemie *Komplexität*

→Chemische Evolution

……

Entstehung erster selbstreprozuzierender Strukturen *leben*

Wie es zu dieser Diplomarbeit kam

Miller-Urey Experiment (1953) Ursuppenversuch

Aus Wasser, Methan und Ammoniak wurden auf der Urerde organische Verbindungen synthetisiert

Juan Oro (1961)

Synthese von Adenin aus Zwischen-produkten des Miller-Urey Experiments

Manfred Eigen

Evolution von RNA-Protein-Ensembles

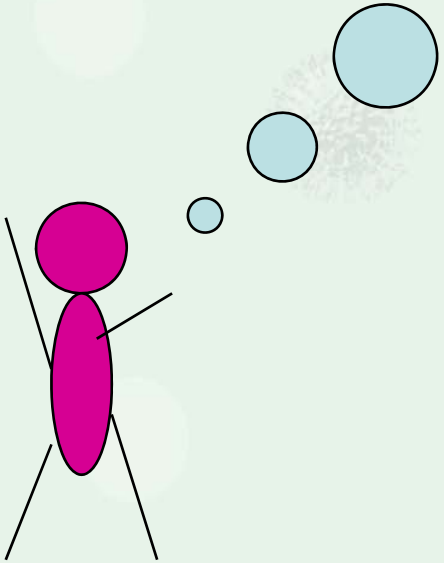
Günter von Kiedrowski

Selbstreplizierendes System auf der Grundlage eines Hexanukleotids (DNA)

NASA-Foto Quelle: Wikipedia

Wie es zu dieser Diplomarbeit kam

Lassen sich nicht auch in komplexen Computer-Systemen Strukturen identifizieren, die sich in einem gewis-
sen Sinn als Leben auffassen l
oder sogar den Einstieg in
Evo



Was macht eigentlich Leben aus ?

Fähigkeit zur identischen Reproduktion auf eigene Veranlassung (Selbstreproduktion)

Möglichkeit zur fehlerhaften Reproduktion (Mutation)

Evolution

Fähigkeit zum Stoffwechsel (+ Regelung)

Programme als Kandidaten für Leben ?

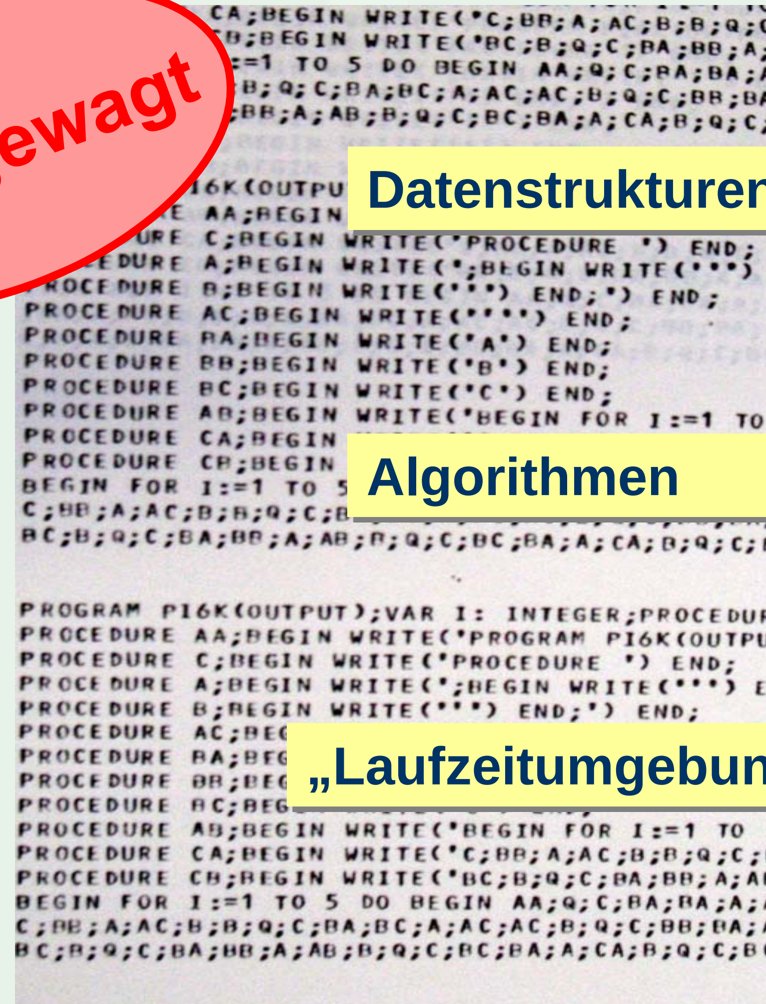
Paramecium Quelle: Wickipedia

Strukturen

Chemische Prozesse

Stoffwechsel +(Regelung)

Sehr gewagt



Datenstrukturen

Algorithmen

„Laufzeitumgebung“

Ziele der Diplomarbeit

Fähigkeit zur identischen Reproduktion auf eigene Veranlassung (Selbstreproduktion)

⇨ **Existenznachweis selbstreproduzierender Programmme in höheren Programmiersprachen**

⇨ **Konstruktion ablauffähiger selbstreproduzierender Beispielprogramme**

mit möglichst kurzem Quellcode

Möglichkeit zur fehlerhaften Reproduktion (Mutation)

Fähigkeit zum Stoffwechsel (+ Regelung)

Definition selbstreproduzierender Programme

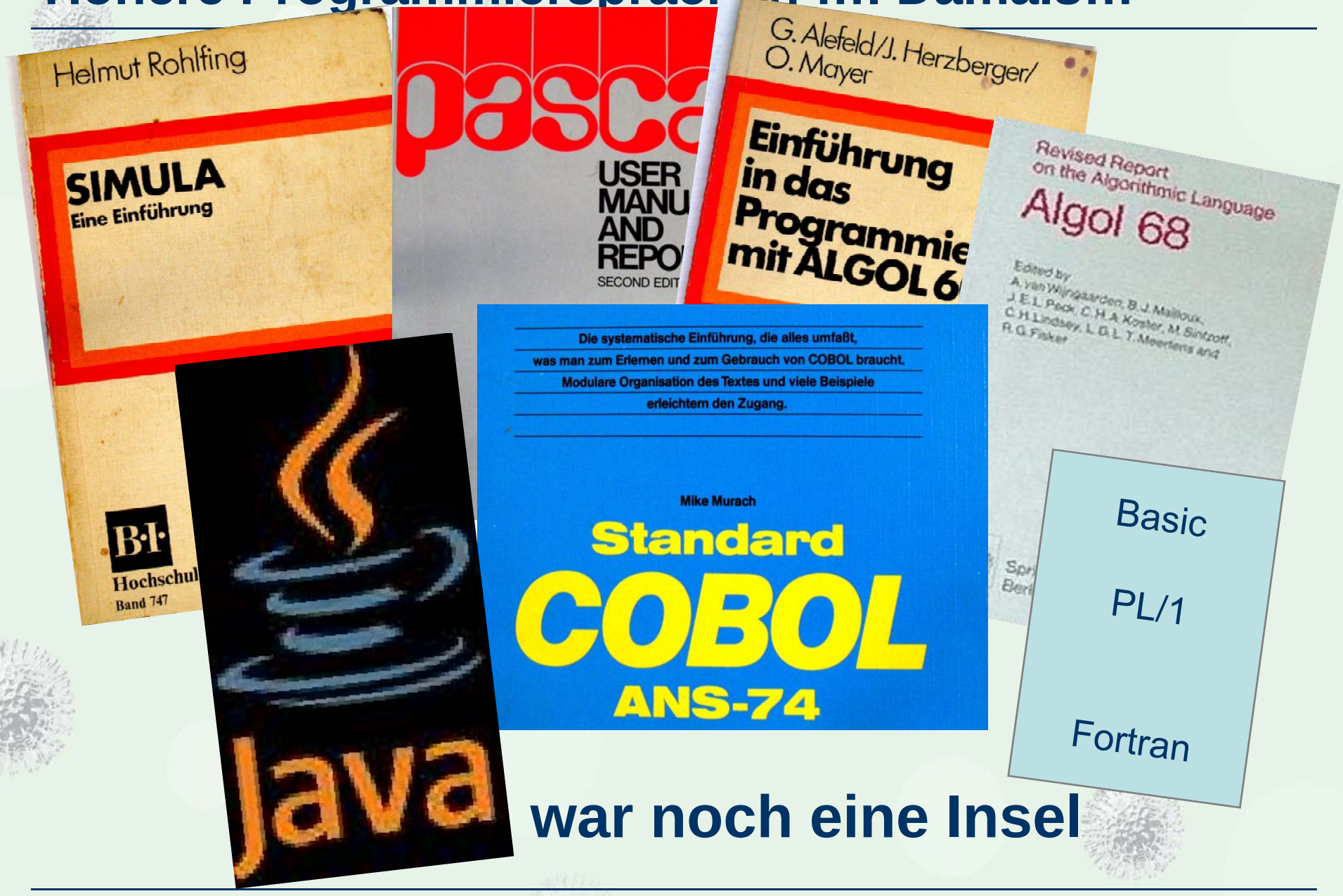
Sei p ein (syntaktisch korrektes) Programm aus der höheren Programmiersprache S

- **Weist p keine Eingabe auf, so heißt p (streng) selbstreproduzierend, falls p (genau) seinen Programmtext in S ausgibt.**

- **Weist p Eingabe auf, so heißt p (streng) selbstreproduzierend, falls p bei jeder zulässigen Eingabe (genau) seinen Programmtext in S ausgibt.**

Der Mechanismus zur Selbstreproduktion muss im Programm selbst verankert sein !

Höhere Programmiersprachen …. Damals…



war noch eine Insel

Sprachliche Unabhängigkeit

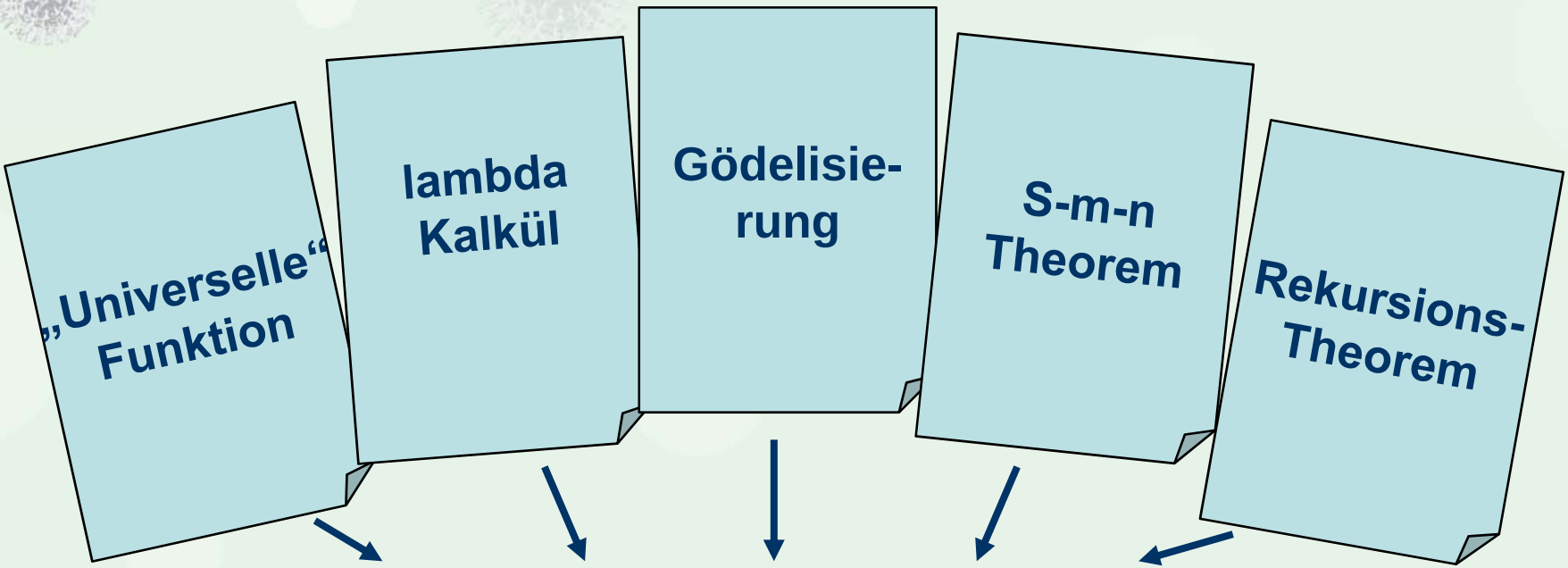
Definition einer abstrakten höheren Programmiersprache PL(A) über einem Alphabet $A=(a_1,\ldots\ldots\ldots,a_n)$

Beschränkung auf einfache Anweisungen in A* wie leere Anweisung, Wort-Zuweisung, Wort um Zeichen verlängern

Beschränkung auf einfache Kontrollstrukturen wie Hintereinanderausführung, if..goto, if..then..else, while-Schleife, loop-Schleife

Menge der mit Programmen aus PL(A) berechenbaren Funktionen = Menge der berechenbaren Funktionen = Menge der partiell rekursiven Funktionen

Existenz selbstreproduzierender Programme



Zu jeder PL (A) berechenbaren Funktion $f: A^* \rightarrow A^*$ gibt

Selbstreproduzierende Programme

existieren

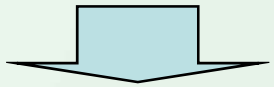
in PL(A) und somit auch in den gängigen höheren Programmiersprachen

Existenz selbstreproduzierender Programme

Der Existenzbeweis hat leider eine kleine Schwäche

Er ist nicht konstruktiv

- → Die Zeichen des **Alphabets A** als Basis von S **anordnen**
- → Ein selbstreproduzierendes Programm p aus S ist ein Wort aus A*. Man kann p also seine zugehörige **Gödelnummer g** zuordnen
- → Aus der Gödelnummer g per Algorithmus sukzessive die Zeichenfolge von p zurückrechnen und ausgeben



Leider $g > 10^{600}$

Konstruktion selbstreproduzierender Programme

Versuch 1: Reproduktion „en bloc“

p_1 = begin OUTTEXT(“ ..... “) end;

An dieser Stelle muß der Programmtext von p_1 stehen also wieder:

begin OUTTEXT(“ ..... “) end;

p_1 = begin OUTTEXT(“ BEGIN OUTTEXT(“ BEGIN OUTTEXT(“.....
..... “) END“)END“ end

p_1 ist leider nicht endlich

Konstruktion selbstreproduzierender Programme

Versuch 2: Totale Zerlegung

p_2 =

```
begin
OUTTEXT(“B“);
OUTTEXT(“E“);
OUTTEXT(“G“);
OUTTEXT(“I“);
OUTTEXT(“N“);
OUTTEXT(“ “);
OUTTEXT(“O“);
……..……
```

Um 1 Zeichen seines Textes auszugeben benötigt p_2 13 Zeichen !

p_2 ist leider auch nicht endlich

Konstruktion selbstreproduzierender Programme

Aber: Selbstreproduzierende Programme existieren !

Vor dem Hintergrund der Existenzaussage muss es also zwischen *„en bloc“* und *totaler Zerlegung* eine „geschickte “ Zerlegung des Progammtextes p in Teilstrings geben,

die es einem geeigneten Algorithmus als Bestandteil von p ermöglicht, den Programmtext p auszugeben.

Der Algorithmus als Bestandteil von p muß offenbar komplexer sein als nur Hintereinanderausführung von Anweisungen, damit p endlich wird.

Kleine Strukturanalyse

9 Teilstrings

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                               2,     22, 3,       3, 12,  11,
                               2, 13, 13, 3, 12,  11,      11,
                               2, 13, 21, 3, 12,  12,      11,
                               2, 13, 22, 3,      13,      11,
                               2, 21, 13, 3,      21,      11,
                               2, 21, 21, 3,      22,      11,
                               2, 21, 22, 3,      23,      11,
                               2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

Kleine Strukturanalyse

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

9 Teilstrings

Kleine Strukturanalyse

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31,  “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

9 Teilstrings

Feldinitialisierung

Kleine Strukturanalyse

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

9 Teilstrings

1 Feldinitialisierung

1 Algorithmus

Kleine Strukturanalyse

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

9 Teilstrings

1 Feldinitialisierung

1 Algorithmus

Kleine Strukturanalyse

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

9 Teilstrings

1 Feldinitialisierung

1 Algorithmus

Kleine Strukturanalyse

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

9 Teilstrings

1 Feldinitialisierung

1 Algorithmus

Kleine Strukturanalyse

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(" BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(" ");
C[ 2 ]:-COPY(" C[ ");
C[ 3 ]:-COPY(" ]:-COPY(" ");
C[ 1 1 ]:-COPY(" "); ");
C[ 1 2 ]:-COPY(" "" ");
C[ 1 3 ]:-COPY(" 1 ");
C[ 2 1 ]:-COPY(" 2 ");
C[ 2 2 ]:-COPY(" 3 ");
C[ 2 3 ]:-COPY(" 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31, ");
C[ 3 1 ]:-COPY(" FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  ");
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

9 Teilstrings

1 Feldinitialisierung

1 Algorithmus

Kleine Strukturanalyse

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END   “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

9 Teilstrings

1 Feldinitialisierung

1 Algorithmus

Syntax-Schikanen

Kleine Strukturanalyse

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END   “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

9 Teilstrings

1 Feldinitialisierung

1 Algorithmus

Syntax-Schikanen

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                               2,     22, 3,       3, 12,  11,
                               2, 13, 13, 3, 12,  11,      11,
                               2, 13, 21, 3, 12,  12,      11,
                               2, 13, 22, 3,      13,      11,
                               2, 21, 13, 3,      21,      11,
                               2, 21, 21, 3,      22,      11,
                               2, 21, 22, 3,      23,      11,
                               2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

Animation

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                               2,     22, 3,       3, 12,  11,
                               2, 13, 13, 3, 12,  11,      11,
                               2, 13, 21, 3, 12,  12,      11,
                               2, 13, 22, 3,      13,      11,
                               2, 21, 13, 3,      21,      11,
                               2, 21, 21, 3,      22,      11,
                               2, 21, 22, 3,      23,      11,
                               2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                               2,     22, 3,       3, 12,  11,
                               2, 13, 13, 3, 12,  11,      11,
                               2, 13, 21, 3, 12,  12,      11,
                               2, 13, 22, 3,      13,      11,
                               2, 21, 13, 3,      21,      11,
                               2, 21, 21, 3,      22,      11,
                               2, 21, 22, 3,      23,      11,
                               2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                                2,     22, 3,       3, 12,  11,
                                2, 13, 13, 3, 12,  11,      11,
                                2, 13, 21, 3, 12,  12,      11,
                                2, 13, 22, 3,      13,      11,
                                2, 21, 13, 3,      21,      11,
                                2, 21, 21, 3,      22,      11,
                                2, 21, 22, 3,      23,      11,
                                2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                           2,     22, 3,       3, 12,  11,
                           2, 13, 13, 3, 12,  11,      11,
                           2, 13, 21, 3, 12,  12,      11,
                           2, 13, 22, 3,      13,      11,
                           2, 21, 13, 3,      21,      11,
                           2, 21, 21, 3,      22,      11,
                           2, 21, 22, 3,      23,      11,
                           2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
               (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
               2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                           2,     22, 3,       3, 12,  11,
                           2, 13, 13, 3, 12,  11,      11,
                           2, 13, 21, 3, 12,  12,      11,
                           2, 13, 22, 3,      13,      11,
                           2, 21, 13, 3,      21,      11,
                           2, 21, 21, 3,      22,      11,
                           2, 21, 22, 3,      23,      11,
                           2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                           2,     22, 3,       3, 12,  11,
                           2, 13, 13, 3, 12,  11,      11,
                           2, 13, 21, 3, 12,  12,      11,
                           2, 13, 22, 3,      13,      11,
                           2, 21, 13, 3,      21,      11,
                           2, 21, 21, 3,      22,      11,
                           2, 21, 22, 3,      23,      11,
                           2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                           2,     22, 3,       3, 12,  11,
                           2, 13, 13, 3, 12,  11,      11,
                           2, 13, 21, 3, 12,  12,      11,
                           2, 13, 22, 3,      13,      11,
                           2, 21, 13, 3,      21,      11,
                           2, 21, 21, 3,      22,      11,
                           2, 21, 22, 3,      23,      11,
                           2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                           2,     22, 3,       3, 12,  11,
                           2, 13, 13, 3, 12,  11,      11,
                           2, 13, 21, 3, 12,  12,      11,
                           2, 13, 22, 3,      13,      11,
                           2, 21, 13, 3,      21,      11,
                           2, 21, 21, 3,      22,      11,
                           2, 21, 22, 3,      23,      11,
                           2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                           2,     22, 3,       3, 12,  11,
                           2, 13, 13, 3, 12,  11,      11,
                           2, 13, 21, 3, 12,  12,      11,
                           2, 13, 22, 3,      13,      11,
                           2, 21, 13, 3,      21,      11,
                           2, 21, 21, 3,      22,      11,
                           2, 21, 22, 3,      23,      11,
                           2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,    21, 3,      2,     11,
                               2,    22, 3,      3, 12, 11,
                               2, 13, 13, 3, 12, 11,     11,
                               2, 13, 21, 3, 12, 12,     11,
                               2, 13, 22, 3,     13,     11,
                               2, 21, 13, 3,     21,     11,
                               2, 21, 21, 3,     22,     11,
                               2, 21, 22, 3,     23,     11,
                               2, 22, 13, 3,     31,     11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                               2,     22, 3,       3, 12,  11,
                               2, 13, 13, 3, 12,  11,      11,
                               2, 13, 21, 3, 12,  12,      11,
                               2, 13, 22, 3,      13,      11,
                               2, 21, 13, 3,      21,      11,
                               2, 21, 21, 3,      22,      11,
                               2, 21, 22, 3,      23,      11,
                               2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                               2,     22, 3,       3, 12,  11,
                               2, 13, 13, 3, 12,  11,      11,
                               2, 13, 21, 3, 12,  12,      11,
                               2, 13, 22, 3,      13,      11,
                               2, 21, 13, 3,      21,      11,
                               2, 21, 21, 3,      22,      11,
                               2, 21, 22, 3,      23,      11,
                               2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                               2,     22, 3,       3, 12,  11,
                               2, 13, 13, 3, 12,  11,      11,
                               2, 13, 21, 3, 12,  12,      11,
                               2, 13, 22, 3,      13,      11,
                               2, 21, 13, 3,      21,      11,
                               2, 21, 21, 3,      22,      11,
                               2, 21, 22, 3,      23,      11,
                               2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,    21, 3,      2,     11,
                               2,    22, 3,      3, 12, 11,
                               2, 13, 13, 3, 12, 11,     11,
                               2, 13, 21, 3, 12, 12,     11,
                               2, 13, 22, 3,     13,     11,
                               2, 21, 13, 3,     21,     11,
                               2, 21, 21, 3,     22,     11,
                               2, 21, 22, 3,     23,     11,
                               2, 22, 13, 3,     31,     11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
               (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
               2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                               2,     22, 3,       3, 12,  11,
                               2, 13, 13, 3, 12,  11,      11,
                               2, 13, 21, 3, 12,  12,      11,
                               2, 13, 22, 3,      13,      11,
                               2, 21, 13, 3,      21,      11,
                               2, 21, 21, 3,      22,      11,
                               2, 21, 22, 3,      23,      11,
                               2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,    21, 3,      2,     11,
                 2,    22, 3,      3, 12, 11,
                 2,13, 13, 3, 12, 11,      11,
                 2,13, 21, 3, 12, 12,      11,
                 2,13, 22, 3,     13,      11,
                 2,21, 13, 3,     21,      11,
                 2,21, 21, 3,     22,      11,
                 2,21, 22, 3,     23,      11,
                 2,22, 13, 3,     31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                 (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                 2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(" BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(" " ");
C[ 2 ]:-COPY(" C[ ");
C[ 3 ]:-COPY(" ]:-COPY(" " ");
C[ 1 1 ]:-COPY(" " "); ");
C[ 1 2 ]:-COPY(" "" ");
C[ 1 3 ]:-COPY(" 1 ");
C[ 2 1 ]:-COPY(" 2 ");
C[ 2 2 ]:-COPY(" 3 ");
C[ 2 3 ]:-COPY(" 1, 1, 12, 11, 2,    21, 3,      2,     11,
                                2,    22, 3,      3, 12, 11,
                                2,13, 13, 3, 12, 11,      11,
                                2,13, 21, 3, 12, 12,      11,
                                2,13, 22, 3,     13,      11,
                                2,21, 13, 3,     21,      11,
                                2,21, 21, 3,     22,      11,
                                2,21, 22, 3,     23,      11,
                                2,22, 13, 3,     31,      11, 31, ");
C[ 3 1 ]:-COPY(" FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
               (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
               2 ELSE 3) END END  ");
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,    21, 3,      2,     11,
                              2,    22, 3,      3, 12, 11,
                              2,13, 13, 3, 12, 11,      11,
                              2,13, 21, 3, 12, 12,      11,
                              2,13, 22, 3,     13,      11,
                              2,21, 13, 3,     21,      11,
                              2,21, 21, 3,     22,      11,
                              2,21, 22, 3,     23,      11,
                              2,22, 13, 3,     31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
               (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
               2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,     2,     11,
                2,     22, 3,     3, 12, 11,
                2, 13, 13, 3, 12, 11,     11,
                2, 13, 21, 3, 12, 12,     11,
                2, 13, 22, 3,     13,     11,
                2, 21, 13, 3,     21,     11,
                2, 21, 21, 3,     22,     11,
                2, 21, 22, 3,     23,     11,
                2, 22, 13, 3,     31,     11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,     2,     11,
                                2,     22, 3,     3, 12, 11,
                                2, 13, 13, 3, 12, 11,     11,
                                2, 13, 21, 3, 12, 12,     11,
                                2, 13, 22, 3,     13,     11,
                                2, 21, 13, 3,     21,     11,
                                2, 21, 21, 3,     22,     11,
                                2, 21, 22, 3,     23,     11,
                                2, 22, 13, 3,     31,     11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12, 11,
                2, 13, 13, 3, 12, 11,      11,
                2, 13, 21, 3, 12, 12,      11,
                2, 13, 22, 3,     13,      11,
                2, 21, 13, 3,     21,      11,
                2, 21, 21, 3,     22,      11,
                2, 21, 22, 3,     23,      11,
                2, 22, 13, 3,     31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12, 11,
                2, 13, 13, 3, 12, 11,      11,
                2, 13, 21, 3, 12, 12,      11,
                2, 13, 22, 3,     13,      11,
                2, 21, 13, 3,     21,      11,
                2, 21, 21, 3,     22,      11,
                2, 21, 22, 3,     23,      11,
                2, 22, 13, 3,     31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                               2,     22, 3,       3, 12,  11,
                               2, 13, 13, 3, 12,  11,      11,
                               2, 13, 21, 3, 12,  12,      11,
                               2, 13, 22, 3,      13,      11,
                               2, 21, 13, 3,      21,      11,
                               2, 21, 21, 3,      22,      11,
                               2, 21, 22, 3,      23,      11,
                               2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                                2,     22, 3,       3, 12,  11,
                                2, 13, 13, 3, 12,  11,      11,
                                2, 13, 21, 3, 12,  12,      11,
                                2, 13, 22, 3,      13,      11,
                                2, 21, 13, 3,      21,      11,
                                2, 21, 21, 3,      22,      11,
                                2, 21, 22, 3,      23,      11,
                                2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                                2,     22, 3,       3, 12,  11,
                                2, 13, 13, 3, 12,  11,     11,
                                2, 13, 21, 3, 12,  12,     11,
                                2, 13, 22, 3,      13,     11,
                                2, 21, 13, 3,      21,     11,
                                2, 21, 21, 3,      22,     11,
                                2, 21, 22, 3,      23,     11,
                                2, 22, 13, 3,      31,     11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                                2,     22, 3,       3, 12,  11,
                                2, 13, 13, 3, 12,  11,     11,
                                2, 13, 21, 3, 12,  12,     11,
                                2, 13, 22, 3,      13,     11,
                                2, 21, 13, 3,      21,     11,
                                2, 21, 21, 3,      22,     11,
                                2, 21, 22, 3,      23,     11,
                                2, 22, 13, 3,      31,     11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                                2,     22, 3,       3, 12,  11,
                                2, 13, 13, 3, 12,  11,      11,
                                2, 13, 21, 3, 12,  12,      11,
                                2, 13, 22, 3,      13,      11,
                                2, 21, 13, 3,      21,      11,
                                2, 21, 21, 3,      22,      11,
                                2, 21, 22, 3,      23,      11,
                                2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                                2,     22, 3,       3, 12,  11,
                                2, 13, 13, 3, 12,  11,      11,
                                2, 13, 21, 3, 12,  12,      11,
                                2, 13, 22, 3,      13,      11,
                                2, 21, 13, 3,      21,      11,
                                2, 21, 21, 3,      22,      11,
                                2, 21, 22, 3,      23,      11,
                                2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                                2,     22, 3,       3, 12,  11,
                                2, 13, 13, 3, 12,  11,      11,
                                2, 13, 21, 3, 12,  12,      11,
                                2, 13, 22, 3,      13,      11,
                                2, 21, 13, 3,      21,      11,
                                2, 21, 21, 3,      22,      11,
                                2, 21, 22, 3,      23,      11,
                                2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
               (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
               2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                                2,     22, 3,       3, 12,  11,
                                2, 13, 13, 3, 12,  11,      11,
                                2, 13, 21, 3, 12,  12,      11,
                                2, 13, 22, 3,      13,      11,
                                2, 21, 13, 3,      21,      11,
                                2, 21, 21, 3,      22,      11,
                                2, 21, 22, 3,      23,      11,
                                2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                                2,     22, 3,       3, 12,  11,
                                2, 13, 13, 3, 12,  11,     11,
                                2, 13, 21, 3, 12,  12,     11,
                                2, 13, 22, 3,      13,     11,
                                2, 21, 13, 3,      21,     11,
                                2, 21, 21, 3,      22,     11,
                                2, 21, 22, 3,      23,     11,
                                2, 22, 13, 3,      31,     11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(" BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(" " ");
C[ 2 ]:-COPY(" C[ ");
C[ 3 ]:-COPY(" ]:-COPY(" " ");
C[ 1 1 ]:-COPY(" " "); ");
C[ 1 2 ]:-COPY(" "" ");
C[ 1 3 ]:-COPY(" 1 ");
C[ 2 1 ]:-COPY(" 2 ");
C[ 2 2 ]:-COPY(" 3 ");
C[ 2 3 ]:-COPY(" 1, 1, 12, 11, 2,     21, 3,      2,      11,
                2,     22, 3,      3, 12, 11,
                2, 13, 13, 3, 12, 11,      11,
                2, 13, 21, 3, 12, 12,      11,
                2, 13, 22, 3,     13,      11,
                2, 21, 13, 3,     21,      11,
                2, 21, 21, 3,     22,      11,
                2, 21, 22, 3,     23,      11,
                2, 22, 13, 3,     31,      11, 31, ");
C[ 3 1 ]:-COPY(" FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
               (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
               2 ELSE 3) END END  ");
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,      2,      11,
                2,     22, 3,      3, 12,  11,
                2, 13, 13, 3, 12,  11,      11,
                2, 13, 21, 3, 12,  12,      11,
                2, 13, 22, 3,      13,      11,
                2, 21, 13, 3,      21,      11,
                2, 21, 21, 3,      22,      11,
                2, 21, 22, 3,      23,      11,
                2, 22, 13, 3,      31,      11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(" BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(" " ");
C[ 2 ]:-COPY(" C[ ");
C[ 3 ]:-COPY(" ]:-COPY(" " ");
C[ 1 1 ]:-COPY(" " "); ");
C[ 1 2 ]:-COPY(" "" ");
C[ 1 3 ]:-COPY(" 1 ");
C[ 2 1 ]:-COPY(" 2 ");
C[ 2 2 ]:-COPY(" 3 ");
C[ 2 3 ]:-COPY(" 1, 1, 12, 11, 2,     21, 3,      2,      11,
                2,     22, 3,      3, 12,  11,
                2, 13, 13, 3, 12,  11,      11,
                2, 13, 21, 3, 12,  12,      11,
                2, 13, 22, 3,      13,      11,
                2, 21, 13, 3,      21,      11,
                2, 21, 21, 3,      22,      11,
                2, 21, 22, 3,      23,      11,
                2, 22, 13, 3,      31,      11, 31, ");
C[ 3 1 ]:-COPY(" FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  ");
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(" BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(" " ");
C[ 2 ]:-COPY(" C[ ");
C[ 3 ]:-COPY(" ]:-COPY(" " ");
C[ 1 1 ]:-COPY(" " "); ");
C[ 1 2 ]:-COPY(" "" ");
C[ 1 3 ]:-COPY(" 1 ");
C[ 2 1 ]:-COPY(" 2 ");
C[ 2 2 ]:-COPY(" 3 ");
C[ 2 3 ]:-COPY(" 1, 1, 12, 11, 2,     21, 3,      2,     11,
                                2,     22, 3,      3, 12, 11,
                                2, 13, 13, 3, 12, 11,     11,
                                2, 13, 21, 3, 12, 12,     11,
                                2, 13, 22, 3,     13,     11,
                                2, 21, 13, 3,     21,     11,
                                2, 21, 21, 3,     22,     11,
                                2, 21, 22, 3,     23,     11,
                                2, 22, 13, 3,     31,     11, 31, ");
C[ 3 1 ]:-COPY(" FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  ");
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31, “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END  “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31,  “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END   “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ “” “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                              2,     22, 3,       3, 12,  11,
                              2, 13, 13, 3, 12,  11,      11,
                              2, 13, 21, 3, 12,  12,      11,
                              2, 13, 22, 3,      13,      11,
                              2, 21, 13, 3,      21,      11,
                              2, 21, 21, 3,      22,      11,
                              2, 21, 22, 3,      23,      11,
                              2, 22, 13, 3,      31,      11, 31,  “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END   “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

```
BEGIN INTEGER I,S,Z; TEXT ARRAY C[1:31];
C[1]:-COPY(“ BEGIN INTEGER I, S, Z; TEXT ARRAY C[1:31];C[1]:-COPY(“ “ “);
C[ 2 ]:-COPY(“ C[ “);
C[ 3 ]:-COPY(“ ]:-COPY(“ “ “);
C[ 1 1 ]:-COPY(“ “ “); “);
C[ 1 2 ]:-COPY(“ ““ “);
C[ 1 3 ]:-COPY(“ 1 “);
C[ 2 1 ]:-COPY(“ 2 “);
C[ 2 2 ]:-COPY(“ 3 “);
C[ 2 3 ]:-COPY(“ 1, 1, 12, 11, 2,     21, 3,       2,      11,
                2,     22, 3,       3, 12,  11,
                2, 13, 13, 3, 12,  11,       11,
                2, 13, 21, 3, 12,  12,       11,
                2, 13, 22, 3,      13,       11,
                2, 21, 13, 3,      21,       11,
                2, 21, 21, 3,      22,       11,
                2, 21, 22, 3,      23,       11,
                2, 22, 13, 3,      31,       11, 31,  “);
C[ 3 1 ]:-COPY(“ FOR I:=1 STEP 1 Until 60 DO BEGIN S:=C[23].SUB
                (Z+1,2).GETINT;OUTTEXT(C[S]);Z:=Z+(IF S<10 THEN
                2 ELSE 3) END END   “);
FOR I:=1 STEP 1 Until 60 DO
    BEGIN S:=C[23].SUB(Z+1,2).GETINT;OUTTEXT(C[S]);
          Z:=Z+(IF S<10 THEN 2 ELSE 3) END END
END END
```

Bauplan

„Genetische Code“

Erkenntnisse

Selbstreproduktion benötigt einen innewohnenden Bauplan, Bauteile, und einen Algorithmus um den Bauplan zu realisieren

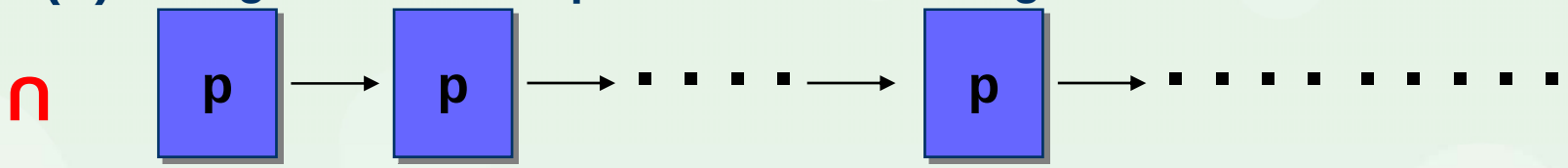
Selbstreproduktion ist im Kern algorithmisch einfach. Es reicht bereits die Schachtelungstiefe $loop_1$ zur Erzielung von Selbstreproduktion

Es gibt keine Selbstreproduktion, die mit $loop_0$ auskommt (bezogen auf die abstrakte Programmiersprache LP(A))

Abgeschwächte Selbstreproduktion

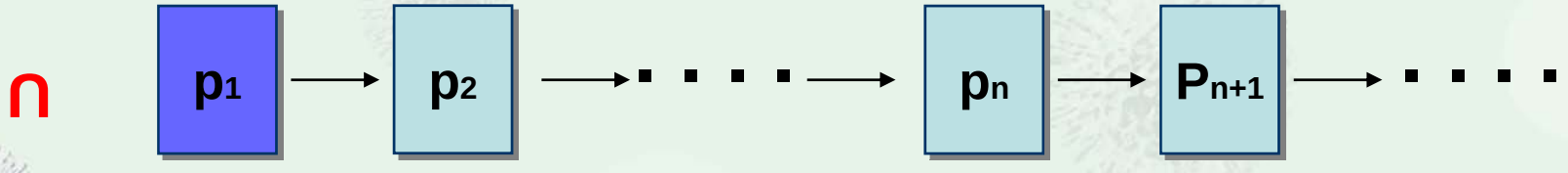
S eine höhere Programmiersprache
p, p‘, p_j syntaktisch korrekte Programme aus S

SR(S): Menge der selbstreproduzierenden Programme

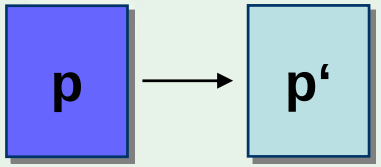


Z(S): Menge der zyklisch selbstreproduzierenden Programme

U(S): Menge der unendlich reproduzierenden Programme



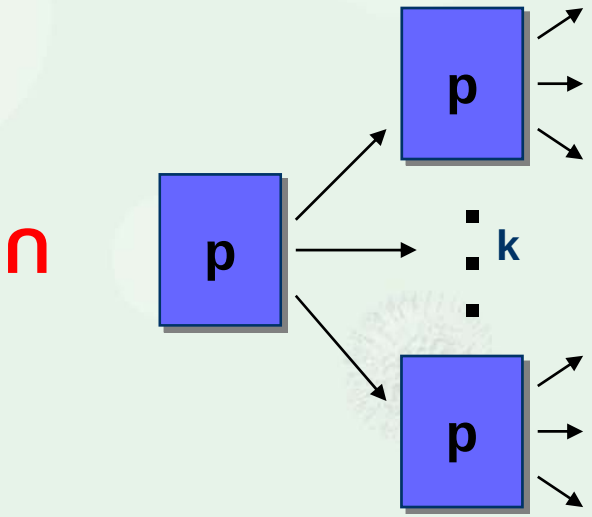
R(S): Menge der reproduzierenden Programme



Verschärfte Selbstreproduktion

S eine höhere Programmiersprache
p, p‘, p_j syntaktisch korrekte Programme aus S

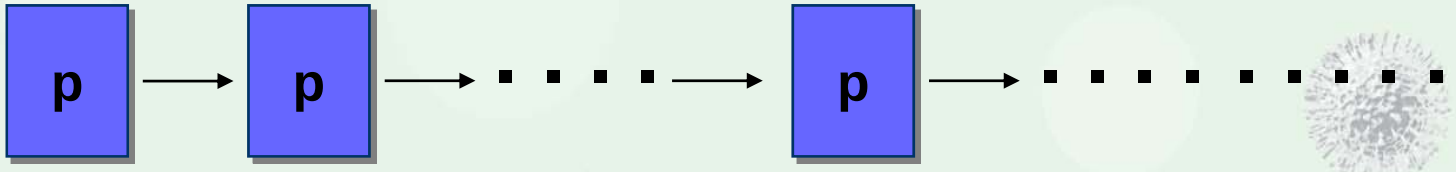
$SR^k(S)$: Menge der k-fach selbstreproduzierenden Programme



Reproduktionshierarchie

$$SR^k(S) \subset SR(S) \subset Z(S) \subset U(S) \subset R(S)$$

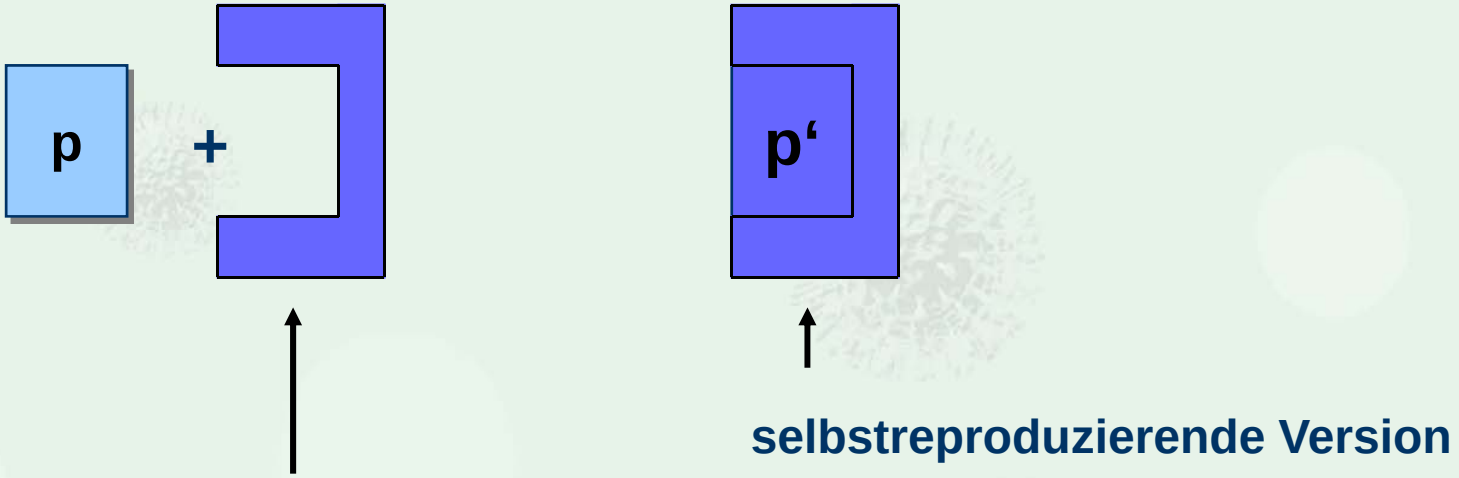
SR(S): Menge der selbstreproduzierenden Programme



Selbstreproduktion mit Zusatzeigenschaften

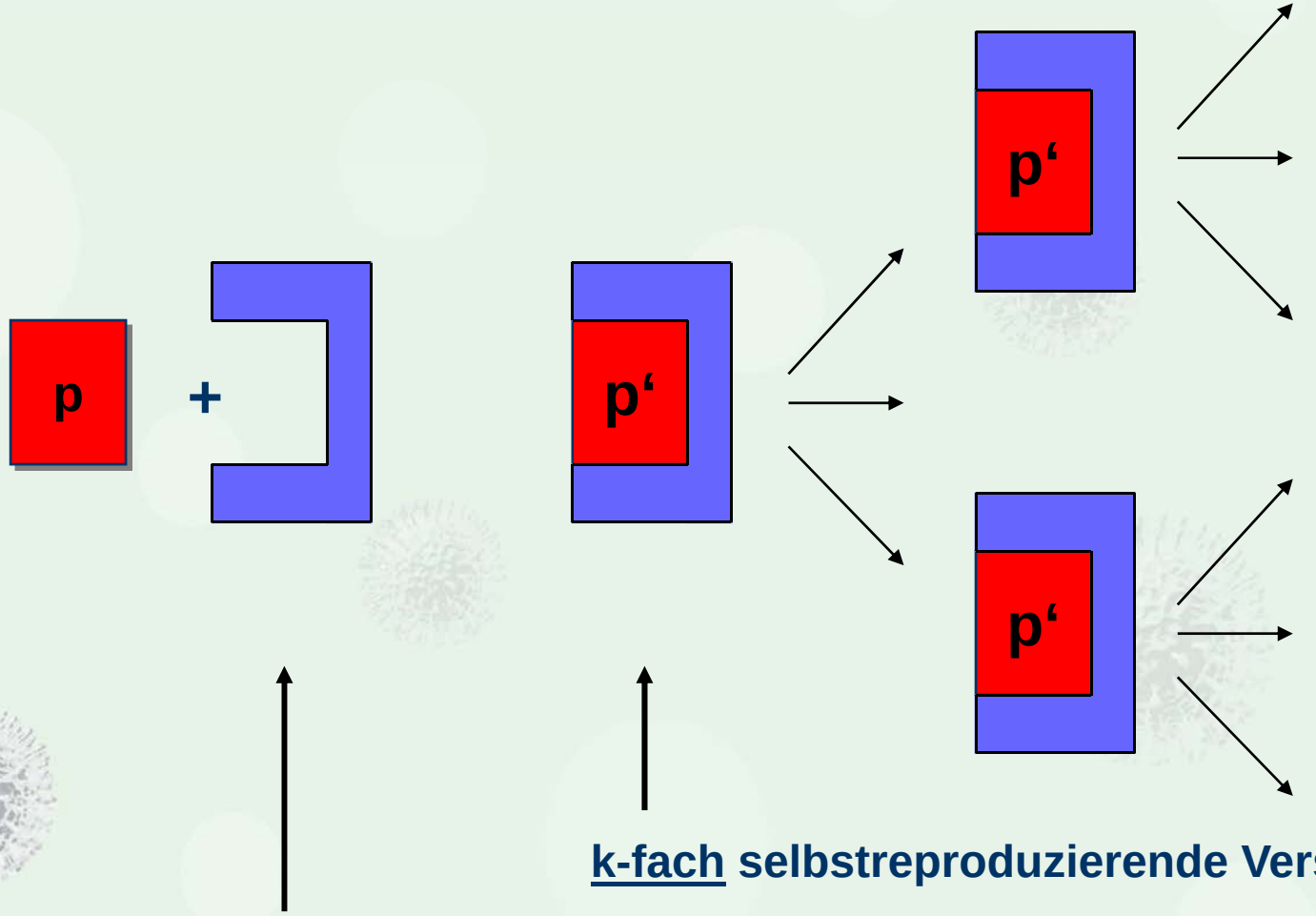
Reproduktionssatz

Zu jedem syntaktisch korrekten Programm p der Programmiersprache Pascal, Simula, …..existiert *formal* eine selbstreproduzierende Version p‘



Selbstreproduktion mit Zatzeigenschaften

Szenario für die Verbreitung von (Schad-) Software



k-fach selbstreproduzierende Version

Code für die Befähigung zur k-fachen Selbstreproduktion

s kürzeste selbstreproduzierende

```
begin
procedure AA ;OUTTEXT(“ begin “);
procedure  C ;OUTTEXT(“ procedure  “);
procedure  A ;OUTTEXT(“ ;OUTTEXT(“ “ “);
procedure  B ;OUTTEXT(“ “ “); “);
procedure AC ;OUTTEXT(“ “” “);
procedure BA ;OUTTEXT(“ A “);
procedure BB ;OUTTEXT(“ B “);
procedure BC ;OUTTEXT(“ C “);
procedure AB ;OUTTEXT(“ AA;C;BA;BA;A;AA;B;C;BC;A;C;B;C;BA;A;A;AC;
           B;C;BB;A;AC;B;B;C;BA;BC;A;AC;AC;B;C;BB;BA;A;BA;B;C;BB;
           BB;A;BB;B;C;BB;BC;A;BC;B;C;BA;BB;A;AB;B;AB END “);
AA;C;BA;BA;A;   AA;   B;
   C;BC;   A;    C;   B;
   C;BA;   A;    A;AC;B;
   C;BB;   A;AC; B;   B;
   C;BA;BC;A;AC;AC;   B;
   C;BB;BA;A;   BA;   B;
   C;BB;BB;A;   BB;   B;
   C;BB;BC;A;   BC;   B;
   C;BA;BB;A;   AB;   B;AB
end
```

Leben selbstreproduzierende Programme ?

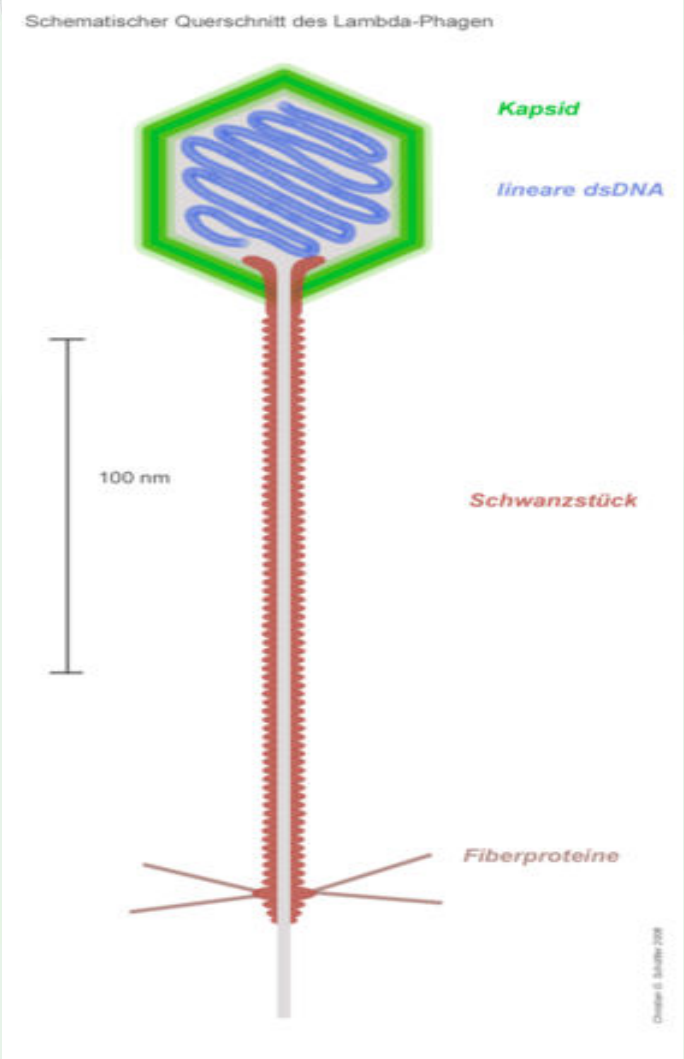
Fähigkeit zur identischen Reproduktion auf eigene Veranlassung (Selbstreproduktion)

Möglichkeit zur fehlerhaften Reproduktion (Mutation)

Fähigkeit zum Stoffwechsel (+ Regelung)

Nein

…….. . Aber da waren doch noch die Viren



Fähigkeit zur identischen Reproduktion auf eigene Veranlassung (Selbstreproduktion)

Möglichkeit zur fehlerhaften Reproduktion (Mutation)

Fähigkeit zum Stoffwechsel (+ Regelung)

Bildbeschreibung: Schematischer Querschnitt durch einen Lambda-Phagen (Virusfamilie Siphoviridae) * Zeichner: Gleiberg * Datum: 2006
Quelle: Wikipedia

Ergebnis

Selbstreproduzierende Programme leben zwar nicht, lassen sich aber unter Einschränkungen mit Viren vergleichen

Seit damals 1987 1992 2007

Vielen

Dank

für

Ihre

Aufmerksamkeit

…….. noch Fragen ?